

PHYSICAL ACTIVITY OF CHILDREN WITH DEVELOPMENTAL COORDINATION
DISORDER IN THE PRESENCE OF ATTENTION DEFICIT HYPERACTIVITY
DISORDER: DOES GENDER MATTER?

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ABSTRACT

Baerg, S., Cairney, J., Hay, J., Rempel, L. and Faught, B.E. (2009). *Physical Activity of Children with Developmental Coordination Disorder in the Presence of Attention Deficit Hyperactivity Disorder: Does Gender Matter?* Brock University, St. Catharines, Ontario, CANADA.

Children with Developmental Coordination Disorder (DCD) have difficulties in motor coordination. Attention-deficit hyperactive disorder (ADHD) is considered the condition most co-morbid with DCD at approximately 50%. Children with DCD are generally less physically active (PA) than their peers, while children with ADHD are often considered more physically active. It is not known if the physical activity patterns of children with DCD-ADHD resemble those of children with primarily DCD or that of their healthy peers. The primary objective of this research was to contrast physical activity patterns between children with DCD, DCD-ADHD, and healthy controls. Since boys are generally reported as more physically active than girls, a secondary objective was to determine if gender moderated the association between groups and physical activity. A sample of males (n=66) and females (n=44) were recruited from the Physical Health Activity Study Team (PHAST) longitudinal study. The Movement Assessment Battery for Children (2nd Ed.) was used to identify probable cases of DCD, and Connor's Revised Parent Rating Scale- Short Version to identify ADHD. Subjects (mean age=12.8±.4 yrs) were allocated to three groups; DCD (n=32), DCD-ADHD (n=30) and control (n=48). Physical activity was monitored for seven days with the Actical® accelerometer (activity count, step count and energy expenditure). Children completed the Participation Questionnaire (PQ) during the in-school session of data collection for the PHAST study. Height, weight and body mass index (BMI) were also determined. Analysis of variance showed significant group differences for activity count ($F(2,56)=5.36$, $p=.007$) and PQ ($F(2,44)=6.71$, $p=.003$) in males, while a significant group difference for step count ($F(2,37)=3.55$, $p=.04$) was found in females. Post hoc comparison tests (Tukey) identified significantly lower PQ and activity count between males with DCD and controls ($p=.004$) and males with DCD-ADHD and controls ($p=.003$). Conversely, females with DCD-ADHD had significantly more step counts than their controls ($p=.01$). Analysis of covariance demonstrated a gender by DCD groups negative interaction for males (activity count) ($F(2,92)=3.11$, $p=.049$) and a positive interaction for females (step count) ($F(1,92)=4.92$, $p=.009$). Hyperactivity in females with DCD-ADHD appears to contribute to more physical activity, whereas DCD may contribute to decreased activity in males with DCD and DCD-ADHD. Further research is needed to examine gender differences in physical activity within the context of DCD and ADHD.

LIST OF ABBREVIATIONS

| | |
|----------------------------|--|
| α | Alpha |
| ADD | Attention Deficit Disorder |
| ADHD | Attention-deficit hyperactive disorder |
| ADHD-PH | Attention-deficit hyperactive disorder-Predominantly hyperactive |
| ADHD-C | Attention-deficit hyperactive disorder-Combined |
| ADHD-PI | Attention-deficit hyperactive disorder-Predominantly inattentive |
| ANCOVA | Analysis of covariance |
| ANOVA | Analysis of variance |
| BMI | Body Mass Index |
| BOTMP | Bruininks-Oseretsky Test of Motor Proficiency |
| CI | Confidence Interval |
| CPRS-R | Connors' Parent Rating Scale-Revised: Short Version |
| CRS | Connors' Rating Scale |
| DCD | Developmental Coordination Disorder |
| DCD-ADHD | Developmental coordination disorder and Attention-deficit hyperactive disorder |
| AEE | Activity Energy Expenditure |
| M-ABC-2 | Movement Assessment Battery for Children (2 nd Ed.) |
| PA | Physical Activity |
| PQ | Participation Questionnaire |

CHAPTER 1 – INTRODUCTION

1.1 Introduction

Developmental coordination disorder (DCD) is a condition where difficulties in motor coordination can affect either or both gross and fine motor ability. This can have a negative impact on handwriting, academic achievement, activities of daily living, or performance in sports (American Psychiatric Association, 1994). A major concern for these children is their diminished levels of habitual physical activity. Children with DCD face daily physical and psychosocial challenges (Skinner & Piek, 2001; Dewey et al., 2002; Piek, Bayman, & Barrett, 2006). A lack of awareness regarding DCD among parents, peers and educators can result in unrealistic expectations of these children's capabilities (Hay & Missiuna, 1998). The impairment in motor function experienced by children with DCD often leads to a handicap. The effect of this disability can be minimized and handicap prevented by modifications to both social and physical environments in order to foster success and reduce frustration. Conditions co-morbid with DCD further complicate the situation. Of note is that approximately 50% of children with DCD may also suffer from attention-deficit hyperactive disorder (ADHD) (Barkley, 1990; Gillberg et al., 2004; Piek et al., 1999; Pitcher, 2003). According to DSM IV criteria, the typical characteristics of ADHD include someone that: 1) often gets up from their seat, 2) often runs about or climbs, and/or 3) often is "on the go" or acts as if "driven by a motor" (APA, 1994). Attention-deficit hyperactive disorder alone has ramifications for habitual physical activity and co-morbid

children will present as complex cases.

Children with DCD generally have lower generalized self-efficacy toward physical activity (Cairney et al., 2005c; Cairney et al., 2007b) and are significantly less active than their peers (Cairney et al., 2005c; 2005b). Conversely, children with ADHD have been reported to be more physically active than their peers (Dane et al., 2000). Yet, our understanding of the habitual physical activity levels of children with ADHD is largely unknown. Furthermore, It is not known if the physical activity patterns of children with DCD co-morbid with ADHD (DCD-ADHD) are different than those of children with a diagnosis of DCD alone. If children with DCD-ADHD are more physically active than those with DCD alone, their hyperactivity might prove to positively influence their levels of physical activity. The characteristics of children with ADHD may make play with their peers more difficult in that their hyperactivity might be expressed as non-purposeful movement. Higher levels of habitual physical activity (PA) have been associated with enhanced psychological well-being as well as improved cardiovascular health (Prafitt & Eston, 2005). Our lack of understanding of the PA levels of children co-morbid with DCD and ADHD makes the development of programs to enhance PA challenging at best.

Few studies have examined gender differences of physical activity within the DCD population. In population-based studies of healthy children, boys commonly demonstrate greater physical activity than girls (Leblanc & Jenssen, 2008; Cairney et al., 2008; Klentrou et al., 2003). This is also believed to hold true for boys with hyperactivity (Porrino et al., 1983). A greater understanding of

physical activity patterns of children with DCD co-morbid with ADHD, with consideration given to gender influences, would be valuable in advancing our knowledge of clumsy children and help to inform intervention strategies that are focused on increasing physical activity in these children for the purpose of improving their psychosocial and physical wellbeing.

1.2 Objectives

The primary objective of the study was to examine whether there are differences in PA in children with DCD, those with co-morbid DCD and ADHD, and healthy controls. A second objective was to determine if gender moderated (influenced) the association between groups and PA.

1.3 Hypothesis

We hypothesize that children with co-morbid DCD and ADHD will be more physically active than children with DCD alone, regardless of gender.

CHAPTER 2 – REVIEW OF LITERATURE

2.1 Developmental coordination disorder

For nearly a century, poor motor coordination in children has been recognized as a developmental problem (Coleman et al, 2001; Miyahara & Register, 2000). These children have been variously classified as 'clumsy', 'awkward', or 'having movement difficulties' (Orton, 1937). In 1987, the term 'Developmental Coordination Disorder' (DCD) was introduced (Missiuna & Polatajko, 1995), and there was consensus regarding two DCD character traits that are generalizable to all children with DCD. First, all children with DCD have dysfluent movement, and second, they all exhibit motor learning difficulties (Lafuze, 1951; McKinlay, 1988; Missiuna, 1994; Wall, Reid, & Paton, 1990; all cited in Cermak et al, 2002). In the early 1990's, Developmental Coordination Disorder was officially recognized in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (American Psychiatric Association, 1994) and criteria established to distinguish DCD as a disorder separate from similar conditions such as apraxia or developmental dyspraxia (Missiuna & Polatajko, 1995; Miyahara & Mobs, 1995). While DCD is sometimes referred to as a 'playground disorder' (Hay & Missiuna, 1998), its effect is felt far beyond the playground alone. These children are at risk for withdrawal or exclusion from physical activity (Hay et al., 2004; Missiuna & Polatajko, 1995), bullying (Smyth & Anderson, 2000), poor academic performance (APA, 1994), and have poor cardiovascular risk profile (Faught et al., 2005; Cairney et al, 2005a).

According to the DSM-IV (American Psychiatric Association, 1994) DCD is defined by the following four diagnostic criteria;

- A. Performance in daily activities that require motor coordination is substantially below that expected given the person's chronological age and measured intelligence. This may be manifested by marked delays in achieving motor milestones (e.g., walking, crawling, and sitting), dropping things, "clumsiness," poor performance in sports, or poor handwriting.
- B. The disturbance in Criterion A significantly interferes with academic achievement or activities of daily living.
- C. The disturbance is not due to a general medical condition (e.g., cerebral palsy or muscular dystrophy) and does not meet criteria for a Pervasive Developmental Disorder.
- D. If Mental Retardation is present, the motor difficulties are in excess of those usually associated with it.

In North America, the prevalence of DCD has been estimated between 6% and 15% among school-age children, making it a very common disorder (Henderson & Henderson 2002; Wilson, 2005). In addition, Taylor (1990) reported a 3:1 ratio of males to females with movement difficulties. This increased male prevalence may be the result of boys being recognized more readily than girls due to social expectation biases (Coakley, 1994). There is no widely excepted diagnostic standard used to identify DCD in the research literature due to both terminology and criteria issues (Hay et al., 2004). Typically, a two step process leads to the diagnosis of children with DCD (Flouris, 2004). An initial referral is based on indicators of movement incompetence either from observation or through the administration of a screening tool (e.g., Children Self-

Perceptions of Adequacy in and Predilection for Physical Activity Scale (CSAPPA) (Hay et al., 2004) followed by a confirmatory motor test (e.g., Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978) or Movement Assessment Battery for Children (Henderson & Sugden, 1992)). Developmental coordination disorder is rarely identified before a child reaches school age. At this point, their lack of coordination becomes more noticeable in an evaluative environment (Cermak et al., 2002). Even in the school setting, however, the disorder is often not noticed by parents or teachers and goes undiagnosed. As a result the child is often subject to unofficial and frequently more damaging labels such as clumsy, awkward, unmotivated or lazy (Cermak et al., 2002). One established consequence is lower levels of physical activity (Cairney et al., 2006a).

2.2 Physical activity of children with DCD

Children with Developmental Coordination Disorder have consistently been found to have low levels of physical activity (Cairney et al., 2005b; Faught et al., 2005; Fisher et al., 2005; Hay et al., 2004; Okely et al., 2001). The low levels of perceived competence and confidence that these children experience may lead them to avoid participating in physical activities as a coping mechanism (Bouffard et al., 1996). For example, Okely et al. (2001) reported that the ability to perform fundamental movement skills, was not significantly related to non-organized physical activity, but was significantly related to participation in organized physical activity among adolescents (ages 13-15 years). Faught et al. (2005)

reported that 27% of the variance in the association between DCD and cardiorespiratory fitness is mediated by physical activity and inactivity. However, all these studies relied solely on questionnaires for determining physical activity level. Only one study used accelerometers to measure habitual physical activity in children with DCD (ages 8-10 years), and found that children's motor proficiency was positively associated with activity counts and percentage of time in moderate to vigorous intensity physical activity (Wrotniak et al., 2006). Both objective and subjective means of measuring physical activity however have confirmed that children with motor difficulties are less active.

There are limited studies that have looked at gender differences within the DCD population. Cairney and colleagues (2005b) noted that parents and/or teachers may identify boys as having motor difficulties sooner than girls as a result of their biased expectations of gender related physical skills/abilities (Hay & Donnelly, 1996; Henderson & Hall, 1982). In one study using a questionnaire to measure energy expenditure, boys with DCD were found to have lower mean energy expenditure than boys without DCD (Poulsen, Ziviani & Cuskelly, 2008). Conversely, a self-report measure of PA used in a study looking at DCD found no gender differences (Cairney et al., 2005b). Since, participation in active play is considered an integral part of the daily life of children, it is important to assess the impact of DCD on the habitual physical activity of children with DCD as it affects both social and physical health. Therefore, more work using objective methods is required to further explore physical activity within the DCD population.

2.3 DCD co-morbid with ADHD

The diagnostic criteria for attention-deficit hyperactive disorder as defined by the DSM-IV (American Psychiatric Association, 1994) are quite detailed, and a summary of the criteria are listed below;

A. Inattention

- Is forgetful in daily activities.
- Has trouble organizing activities
- Avoids doing things that take a lot of mental effort.
- Is easily distracted.
- Does not give close attention to details or makes careless mistakes in schoolwork, work, or other activities.
- Has trouble keeping attention on tasks or play activities.

B. Hyperactivity

- Fidgets with hands or feet or squirms in seat.
- Gets up from seat when remaining in seat is expected.
- Runs about or climbs when and where it is not appropriate.
- Often has trouble playing or enjoying leisure activities quietly.
- Is often "on the go" or often acts as if "driven by a motor."

C. Impulsivity

- Interrupts or intrudes on others.

Note that some combinations, and not all, of the above are needed to establish a diagnosis. Based on these criteria, ADHD has been further categorized into three subtypes:

1. *Combined*: both inattention and hyperactivity are present.
2. *Predominantly Inattentive*: inattention is present, but hyperactivity is not.
3. *Predominantly Hyperactive-Impulsive*: hyperactivity is present, but inattention is not.

In North America, the estimated prevalence of ADHD in general population school-aged children is between 5 and 10% (Biederman, 2005). The rate of

overlap between DCD and ADHD is approximately 50% (Barkley, 1990; Gillberg et al., 2004; Piek et al., 1999; Pitcher, 2003). Martin et al., (2006) studied 1285 families of twins aged 5-16 years to determine if subtypes of ADHD are linked to DCD and to what degree. They found the ADHD-PI subtype to have the strongest link to DCD's fine motor and coordination challenges (Martin et al., 2006). In the literature, the definition of ADHD and its subtype Attention Deficit Hyperactivity Disorder-primarily inattentive (ADHD-PI) has been controversial (Martin et al., 2006), and it has been suggested that ADHD-PI is essentially Attention Deficit Disorder; a distinct disorder from ADHD (Diamond, 2005). For the purpose of this paper, both to avoid confusion and the constraints of small sample size, ADHD will be considered as a unitary disorder.

2.4 Physical activity of children with ADHD

While physical activity has been demonstrated to be effective in promoting calmness among children with ADHD (Azrin et al., 2006), little research has examined the habitual physical activity patterns of children with ADHD. Dane (2000) using actigraph found that children with ADHD were significantly more active than controls with no differences between ADHD subtypes. Using a portable solid-state monitor, Porrino et al. (1983) found that boys with hyperactivity had higher levels of motor activity than controls. Research in the field of ADHD and motor skill has focused more on boys, and one study found that diminished fine motor skills have been attributed to poor motor ability in boys (Pitcher et al., 2003).

The above findings are in contrast to the literature that has focused on obesity among children with ADHD. If inactivity can be considered as a predictor of obesity (Klentrout, Hay & Plyley, 2003), some insight can be gained by looking at obesity rates among children with ADHD. Cortese and colleagues (2008) in a review of this literature noted that six of the studies found children with ADHD to be heavier, but that these studies did not report their findings separately by gender. A gender difference may exist, since three studies reported that boys with ADHD were heavier than their peers, and this difference was not found in the single study examining obesity among girls with ADHD. Furthermore, these studies did not report the level of physical activity engaged in by the children. Subsequently, at this time we have very little knowledge of the physical activity habits of children with ADHD and none for those co-morbid with DCD and ADHD.

2.5 Gender differences in physical activity levels

A review of literature demonstrates that gender differences in the physical activity patterns of children have consistently been reported (Hay, 1992; Klentrout et al., 2003). For example, research by Cairney and colleagues (2005b) suggested that the difference between males and females could be a result of socialization, in that girls may be less externally motivated toward sport participation than boys (Coakley, 1994; Lirgg, 1991), and that boys place more priority on athletics in defining oneself (Chase & Dummer, 1992). Studies have repeatedly shown that girls are more sedentary and participate in fewer vigorous activities than males do regardless of their age (Bradley et al. 2000; Caspersen et al. 2000). The lack

of participation in sporting activities for girls may be due to a lower level of enjoyment in physical activity (Klentou et al., 2003). Conversely, Cardon and De Bourdeaudhuij (2008) found no gender differences in mean activity counts and minutes in moderate to vigorous physical activity in their accelerometer-based study measuring the physical activity levels of 76 preschool children (ages 4 to 5). The varied findings provide reason to explore this area further, particularly in the area of DCD. Since gender has been recognized playing a significant role in the physical activity habits of children within the general population, this research will consider gender differences as a potentially powerful influence.

2.6 Assessing physical activity of children

Physical activity is defined as any voluntary bodily movement that results in energy expenditure beyond basal metabolism (Caspersen et al., 2000). When choosing an assessment tool for physical activity, it is important to consider the cohort of interest (Kowalski et al., 1997). Physical activity under free-living conditions is difficult to assess, especially in children, due to the sporadic nature of their movements (Kohl et al., 2000; Sallis & Saelens, 2000). Generally, measures should place minimal burden on both caregiver and child. This is particularly true for preadolescent populations (Hay & Cairney, 2006). Assessing habitual physical activity in children is commonly carried out using either subjective (e.g., questionnaires) or objective methods (e.g., accelerometers or pedometers) (Sirard & Pate, 2001).

2.6.1 Self-reported physical activity

Many self report techniques such as questionnaires, interviewer administered questionnaires, proxy-reports by parents or teachers and diaries are currently available for the assessment of physical activity (Sirard & Pate, 2001). Self-reported PA is most widely used in epidemiologic research due to the ease and low costs of implementation (Armstrong & Welsman, 2006). Physical activity questionnaires seek specific information on the nature, frequency, and duration of participation in activities (Booth et al., 2002). There are also instruments that focus on estimations of the duration and intensity of all forms of activity (Hay & Cairney, 2006). Other questionnaires examine physical activity by recalling one to seven days of exercise (Sallis et al., 1993). Further, if estimates of intensity, frequency and duration are probed, energy expenditure can be estimated (Godin & Shepherd, 1985).

Disadvantages of self-report methods include concerns with accuracy of recall and individual interpretation, as well as social desirability and expectation biases (Kohl et al., 2000; Sirard & Pate, 2001). A recent study by Leblanc and Jenssen (2008) found that moderately to highly physically active children tend to over-estimate their daily physical activity behavior. Conversely, low physically active children demonstrated a tendency to under-estimate daily physical activity. Further, Leblanc and Jenssen found this affect more pronounced in boys than in girls. Considering the questionable validity of self-report methods at younger ages, this approach should be used with caution in ages 10 to 15 years (Sallis & Owen, 1999).

Information from self-report in this age group may still provide important data to supplement objective measures of physical activity behavior, particularly regarding information about nature and frequency. The Participation Questionnaire (PQ) is a 61-item tool that allows children to report their level of participation in three categories: free-time activity, organized sports, and sedentary pursuits. The organized sports section covers a 1-year period of participation, and the free-time items cover usual pastime choices within a typical day or week. The PQ demonstrates a strong test-retest reliability (0.81) for grades four to eight in measuring PA, is gender neutral, and has shown good concurrent validity (0.62) with teacher evaluations of PA (Hay, 1992).

2.6.2 Accelerometers

The Actical activity monitor uses an accelerometer to measure PA in three axes in addition to providing step-counts from a pedometer. Accelerometers and pedometers are not without weakness. For example, in determining energy expenditure, a pedometer cannot differentiate between steps on various grades (Vanhees et al., 2005). Depending on placement, accelerometers cannot measure upper body movements (Vanhees et al., 2005), and are unable to provide information on the nature, duration or intensity of activity. Therefore, both accelerometers and pedometers are best employed in a multi-method evaluation of PA by using step counts from pedometers and accelerometer data that converts an individual's accelerated movement to a quantifiable value (Sirard & Pate, 2001; Vanhees et al., 2005).

Initially, accelerometers were uni-axial, but more recent models measure movement in three planes (tri-axial) (Armstrong & Welsman, 2006). Eston and colleagues (1998) examined the relationship between oxygen consumption and output from tri-axial and uni-axial accelerometers in children during walking, running and unregulated play activities. They found the tri-axial accelerometer exhibited a stronger correlation with oxygen consumption ($r=0.91$) than did the uni-axial accelerometer ($r=0.78$). All accelerometers have limitations for complex movements of the upper body. Placement of accelerometers on the hip at the midaxilla line has been established as the most accurate placement site (Nilsson et al, 2002; Ward et al, 2005).

Accelerometers can be used to measure activity count and energy expenditure (AEE) and to classify physical activity into defined intensity levels (Sun et al., 2008; Puyau et al., 2004). Energy expenditure is considered energy used during “activity” beyond that required for basal metabolism. However, numerous factors contribute to energy expenditure when calculated by accelerometers. These include economy of movement and body weight (Schutz, Weinsier & Hunter, 2001). Ekelund et al. (2002) noted elevated energy expenditure results in obese children, despite having participated in lower levels of physical activity under similar workload conditions. They concluded that energy expended is associated with, but not equivalent to PA and that interpretation of energy expenditure as a proxy measure for PA should be cautioned. Nevertheless, waist-mounted accelerometers are commonly used to measure the physical activity behaviours of children as the unit is small, light-

weight and comfortable (Kohl et al., 2000; Freedson et al., 2005).

2.7 Summary

This review summarized the challenges that children with DCD encounter on a daily basis, specifically, their avoidance of physical activity. The high prevalence of children with DCD co-morbid ADHD was also established. The physical activity level of children with ADHD is not well understood but appears to contrast with those of children with DCD and possibly exceed those found among healthy controls. The impact of gender on physical activity in both children with DCD and ADHD is unclear. Further, research examining the specific physical activity levels of children co-morbid DCD and ADHD has not been investigated. The challenges in measuring physical activity have been presented and rationale for multi-method approaches presented.

CHAPTER 3 – METHODS

3.1 Research design

The primary objective of the study was to examine PA in children with DCD, those with co-morbid DCD and ADHD, and healthy controls. A second objective was to determine if gender moderated the association between groups and PA. This cross-sectional design made use of data collected in the Physical Health Activity Study Team (PHAST) longitudinal study. The sample population consisted of 2260 Grade Seven school aged children recruited from elementary schools across the District School Board of Niagara (DSBN). Ethics approval was provided by Research Ethics Boards at both Brock University (Appendix 1) and the DSBN.

3.2 Study sample

Appendix 2 outlines the potential DCD sample size estimate based on an initial cohort of 2260 children participating in the PHAST project. Based on a period prevalence of DCD (5.1% (95%CI, 3.5-7.4)) from the PHAST project, the sample size was estimated at 18 subjects per group, considering a 95% confidence level ($\alpha=0.05$) and maximum error of 10%. Nevertheless, this study attempted to include as many children previously identified with probable DCD as possible. A total of 115 (5.1%) children identified with probable DCD using a conservative Bruininks-Oseretsky percentile rank below the 11th percentile and matched control children of similar age received a telephone call to participate in a

laboratory health assessment (Appendix 3). A total of 62 children with DCD (54% positive response rate) and matched controls (62) agreed to participate in the study. Children were identified with probable ADHD using the Connors \parent Rating Scale- Short Version and for the purpose of our research objective, we chose to include only those children with DCD (32), ADHD (30) and 48 matched control subjects. Additionally, of the matched control subjects (62), 14 children were identified with ADHD only and excluded from the analysis. These subjects (14) were excluded since the prevalence of ADHD within this group in our study was 22.6%, making this group not representative of the estimated prevalence of general population school-aged children (5-10%) (Biederman, 2005).

3.3 Study logistics and measurement tools

Verbal consent was provided by the parent during a pre-assessment telephone invitation. Written authorization of their consent upon their arrival to the laboratory was provided by the child (Appendix 4) and parent(s) (Appendix 5). The laboratory health evaluation is multifaceted, including a large battery of physiologic and survey-based assessments. For clarity and brevity, only those assessment tools required for the purpose of this investigation are described below.

3.3.1 Physical measures

Body composition: Anthropometric measures of height and weight were conducted in a private body composition room and in the presence of the child's

parent(s) to ensure privacy to all subjects. Height was measured using a stadiometer (Ellard Instrumentation Ltd.) with the child standing without shoes, eyes forward, shoulders relaxed and arms at their side. Height was measured and recorded to the nearest 0.1 cm from the top of the head. Body weight was measured and recorded to the nearest 0.1 kg with a Tanita™ electronic medical scale. The child was wearing only socks and light-weight clothing. Height and weight measurements were used to calculate BMI (kg/m^2).

Motor coordination and DCD designation: Motor coordination was assessed by a certified pediatric Occupational Therapist (OT) using the Movement Assessment Battery for Children, 2nd Edition (M-ABC-2) (Appendix 6). The M-ABC-2 has been updated with new norms, and the ability to assess an extended age range with more task-age overlap (Henderson, Sugden, & Barnett, 2007). The M-ABC-2 was used to assess both fine and gross motor coordination (Henderson, Sugden & Barnett, 2007). The Movement Assessment Battery for Children is the most frequently used standardized motor test to screen for identifying children with DCD in research (Wilson, 2005) and has been used in assessing motor proficiency in children (ages ranging from 4-17 years) with a high standard of reliability (Crawford et al., 2001; Tan et al., 2001; Smits-Engelsman et al., 2008). The updated test consists of eight tasks (items) which are grouped under three headings, including manual dexterity, which has three subtests; (2) ball skills that have two subtests; and (3) static and dynamic balance, which has three subtests. For each item, a standard score is provided. From each of these standard scores, a cumulative impairment score (age adjusted) and percentiles are

provided (Henderson, Sugden & Barnett, 2007). Children with a score at or below the 15th percentile were identified as DCD cases.

Accelerometry: Actical activity monitors have been established as a valid measure of children's step-count and activity energy expenditure, and can be used to discriminate between sedentary, light, moderate and vigorous levels of physical activity (Esliger et al., 2007; Puyau et al., 2004). Children were fitted with the Actical activity accelerometer (Actical, Version 2.0, Mini Mitter, Respironics) to wear for a 7-day period following their visit to Brock University. The child was given an accelerometer attached to a flexible waist belt with instructions on how to wear and care for the unit. The unit on the belt was positioned on the hip at the mid-axilla line, which has been proven to be the most accurate placement (Nilsson et al, 2002; Ward et al, 2005). The child's parent(s) were provided with a 7-day log to record wakeup times, when the unit was removed/replaced (bathing, swimming, or other reasons), and bedtime (Appendix 7). The accelerometer was collected from the child's home 7 days following the lab visit. Data were downloaded to a computer in the lab and the accelerometer was reformatted for the next subject. All units were programmed individually for name, age, gender, height, and weight. The Actical uses an omni-directional sensor with sensitivity to motion in all directions. This type of sensor integrates the amplitude and frequency of motion and produces an electrical current that varies in magnitude (Actical Instruction Manual, 2006). Therefore, an increased intensity of motion produces an increase in voltage. The Actical reports this information in the form of activity counts. Activity energy expenditure (AEE) is

calculated by taking into account the duration, frequency and intensity of an activity (Neilson et al., 2008). The Actical converts movement (activity counts) into energy units (kilocalories), thereby calculating activity energy expenditure. Activity was recorded in 30 second epochs for total daily activity counts, and energy expenditure calculated for each day. Seven day sampling has been shown to be the most valid estimate of a child's habitual physical activity (Trost et al., 2001).

3.3.2 Survey measures

Participation Questionnaire: All the students were enrolled in the PHAST study, and responses to the Participation Questionnaire (PQ) that had been previously completed three to six months prior to the laboratory assessment were accessible (Appendix 8). Though the questionnaire provides separate scores for free play, organized sports, and inactivity, for the purpose of this study, the PQ total score was selected to reflect only the level of participation in volitional free play, and organized sports, and omits activity from chores or school transport. The PQ total score is derived from a larger more in depth 63-item measure that assesses participation in free play, organized sports, and sedentary pursuits (Hay, 1992). Appendix 8 and 9 shows both the questionnaire and the scoring method, respectively. The PQ total score can range from zero to 45. Six items provide an inventory of participation in organized sports and recreational pursuits (e.g., intra-mural sports, inter-school sports, community sports teams, sport clubs, dance clubs and sport/dance lessons). The PQ has demonstrated strong

construct validity with expected gender and urban/rural differences present (Klentrout, Hay, & Plyley, 2003; Hay, Hawes & Faught, 2004; Hay, 1992), as well as significant correlations with body fat, motoric competence, and other health outcomes (Klentrout, Hay, & Plyley, 2003). Criterion validity has been established using correlations with teacher evaluations of activity (0.62) (Hay, 1992). Reliability of the PQ among elementary school children was established with a two-week test-retest reliability of 0.81 (Hay, 1992).

Revised Connors' Parent Rating Scale: The Revised Connors' Parent Rating Scale (CPRS-R) is a tool used to identify children with ADHD. The scale provides two options for parents to complete either the short (27 items) or long (93 items) versions. In light of the fact that parents were completing numerous surveys as a part of the larger laboratory study the short version was administered in order to minimize respondent burden. The short version takes approximately 15 minutes to complete. The CPRS-R short version is comprised of a subset of scales allowing for a comprehensive collection of information, relevant to the DSM-IV criteria. The 27 questions have four possible responses; 1) not true at all (score=0), 2) just a little (score=1), 3) pretty much true (score=3), or 4) very much true (score=4) (Appendix 10). Each question is allocated to one of the four subscales; oppositional, inattention/cognitive problems, hyperactivity, or ADHD Index, and the sub-scores are summed (Conners et al., 1998). The raw score sum is then converted into a T-score which is used to indicate the corresponding percentile. Scores at the 60th percentile or greater indicate the

presence of characteristics for that subscale. The CPRS-R has demonstrated strong utility for screening, diagnosis and in baseline measurements for pharmaceutical interventions; making it useful in clinical and population-based research (Conners et al., 1998). The CPRS-R demonstrates high sensitivity (92%), specificity (94.5%) and overall accuracy (93.4%) in boys and girls (ages 3-17 years) (Conners et al., 1998).

3.4 Statistical analyses

Descriptive statistics were conducted for DCD, DCD-ADHD and control subjects by gender for all physical activity indices, BMI and weight. To address the first objective of the study, ANCOVA was used to analyze both the main effect and interaction of gender by diagnostic groups on physical activity. Age was not included as a covariate as subjects were matched by age within three months. BMI was identified as a covariate in the ANCOVA as BMI had been previously identified as a potential confounder for physical activity (Cairney et al., 2008; Cairney et al., 2007a). BMI was not used as a covariate in the ANCOVA for energy expenditure since this measure is weight adjusted already. In order to examine differences in physical activity among DCD, DCD-ADHD and control groups (objective 1), we used an analysis of variance to determine mean differences of physical activity as measured by step count, activity count, energy expenditure and participation questionnaire total score. Tukey post-hoc analysis was used to identify significant differences between diagnostic groups (e.g., DCD versus DCD-ADHD). Level of statistical significance was set at $p \leq 0.05$.

CHAPTER 4 - RESULTS

4.1 Data management and cleaning

All raw data was initially entered into an excel spreadsheet. Scatter plots of the data were created for all continuous variables; step count, activity count, activity energy expenditure and PQ total, for the whole sample, and by the individuals' diagnostic groups (e.g., DCD, ADHD-DCD, controls). One outlier was identified as an inputting error for the M-ABC-2 percentile score and correct data were confirmed with the original M-ABC-2 responses and substituted into the dataset. Once all data was cleaned the spreadsheet was then imported into a SPSS (version 16) data file.

4.2 Sample characteristics

Table 4.1 shows the characteristics for the entire sample categorized into three groups; DCD, DCD-ADHD, and control subjects. This study was part of a larger clinical-based prospective case-control design examining the cardiovascular health of children with DCD and matched controls. A sample of 124 subjects (mean age=153.9±4.8 months), including 62 children with DCD and matched controls based on age, gender and school were initially included in this study. However, for the purpose of our research objective, we chose to include only those with DCD only (32), DCD-ADHD (30) and 48 control subjects. Fourteen subjects with ADHD only were excluded for the following reasons. First, this group was too small for any meaningful analysis, particular once groups were

stratified by gender. Second, the exaggerated prevalence of ADHD within our control group (22.6%) would have made this group unrepresentative of the general population, considering the prevalence of ADHD in school-aged children is 5-10% (Biederman, 2005). Finally, the study did not have access to information regarding a diagnosis of ADHD prior to the onset of the study. Children were identified with ADHD through the completion of the CPRS which occurred at the lab visit, furthermore, it was not the intent of this study to identify children with ADHD alone and contrast their PA habits as a separate group.

We adopted accelerometer inclusion criteria based on previous studies (CAPANS, 2003 as cited in Hands et al. 2004; Tudor-Locke & Myers, 2001). Data was excluded if the subject wore the accelerometer; 1) less than 600 minutes (10 hours) per day, 2) less than 1000 or more than 40000 steps per day, and/or 3) less than 5 days over a 7 day period. Complete data from the accelerometers were available for 31 (96.9%) subjects from the DCD group, 23 (76.7%) from the DCD-ADHD, and 45 (93.8%) from the controls, and 11 subjects were excluded based on these criteria. Analysis of variance found no significant differences in the number of days that the accelerometers were worn during the seven day period in which the subjects had possession of the units between the three groups; DCD group (6.06 ± 0.9 days), DCD-ADHD (6.35 ± 0.8 days), and controls (6.33 ± 0.8 days), and the average number of minutes that the accelerometers were worn each day; DCD group (797.56 ± 48.2 minutes), DCD-ADHD (793.66 ± 48.3), and controls (810.93 ± 39.6). There was also data missing data for the PQ. Therefore, complete data was available for 21 (65.6%) subjects

from the DCD group, 24 (80.0%) from the DCD-ADHD, and 41 (68.8%) from of the controls.

Table 4.1 Subject characteristics (n=110)

| | DCD (32) n (%) | DCD-ADHD (30) n (%) | Controls (48) n (%) |
|----------------------------|-------------------|------------------------|------------------------|
| Males | 20 (62.5%) | 16 (53.3%) | 30 (62.5%) |
| Females | 12 (37.5%) | 14 (46.6%) | 18 (37.5%) |
| | <u>Mean (sd)</u> | <u>Mean (sd)</u> | <u>Mean (sd)</u> |
| Age (months) | | | |
| Males | 154.4±5.8 | 156.7±5.2 | 154.7±3.4 |
| Females | 152.0±5.6 | 152.9±3.8 | 151.2±3.9 |
| M-ABC-2 (percentile score) | | | |
| Males | 3.96±3.4 | 2.69±2.8 | 45.17±21.1 |
| Females | 4.63±3.2 | 3.94±4.1 | 42.39±21.2 |
| M-ABC-2 (total test score) | | | |
| Males | 45.70±12.84 | 45.50±8.34 | 77.20±7.97 |
| Females | 49.92±10.79 | 44.93±13.70 | 76.61±8.07 |
| ADHD Index | | | |
| Males | 11.14±4.0 | 21.25±3.9 | 6.20±7.2 |
| Females | 5.17±3.2 | 15.36±5.1 | 4.50±2.6 |
| Hyperactivity Score | | | |
| Males | 2.70±1.8 | 5.81±4.7 | 1.80±1.8 |
| Females | 1.25±1.3 | 5.36±3.1 | 2.28±2.2 |
| BMI (kg/m ²) | | | |
| Males | 23.8±5.9 | 23.6±7.7 | 19.3±3.5 |
| Females | 23.2±4.7 | 22.7±5.4 | 20.7±4.7 |
| Weight (kg) | | | |
| Males | 62.4±18.6 | 59.7±22.0 | 50.7±10.7 |
| Females | 57.3±14.3 | 56.6±16.4 | 51.0±14.1 |

Co-morbid DCD-ADHD was present in nearly half of the children with DCD (48.4%), which is consistent with the literature (Gillberg et al., 2004; Barkley, 1990). Though not significant, the motor coordination (M-ABC-2) mean was lowest in DCD-ADHD subjects (3.27 ± 3.5 percentile), the DCD-ADHD males' mean was lower than the DCD-ADHD females, and the DCD males were less coordinated than their female counterparts. Finally, BMI was greater in DCD ($p < 0.05$) and DCD-ADHD subjects ($p < 0.05$) compared to controls.

4.3 Association among study variables

We explored simple, bivariate correlations between all study variables (Appendix 11). Considering the study's objectives, it was important to review the association between different measures of physical activity (self-report, direct measure) with motor coordination. In males, the M-ABC-2 was moderately correlated with PQ ($r = .518$, $p < 0.01$), but only minimally correlated with activity count ($r = .353$, $p < 0.01$) (Cohen, 1988). No significant correlation existed for PQ or activity count in females. No correlation was identified between M-ABC-2 percentile and total energy expenditure for either gender. With regard to the association between different measures of physical activity, the strongest correlation existed between step count and activity count ($r = .710$, $p < .01$) for males and moderately ($r = .598$, $p < .01$) for females. Further, a positive correlation existed between activity count and AEE for males ($r = .475$, $p < .01$) and females ($r = .612$, $p < .01$). The PQ was moderately correlated with step count ($r = .502$, $p < .01$) in males. Finally, BMI was inversely associated with M-ABC-2 in males ($r = -.383$, $p < .01$).

4.4 Relationship between group, gender and physical activity

The first objective was to determine if gender moderated (influenced) the association between groups and PA. We conducted an analysis of covariance (ANCOVA) to address this objective. The PA measures included the PQ total score (PQ) and daily average accelerometer measures of activity energy expenditure (AEE), activity count and step count. These results are shown in Table 4.1. Both a main effect for a gender ($p \eta^2 = .051$, $p = .03$) and a gender by DCD groups ($p \eta^2 = .063$, $p = .05$) interaction was observed for activity count. Similarly, a gender ($p \eta^2 = .046$, $p = .04$) and gender by DCD groups interaction ($p \eta^2 = .097$, $p = .009$) was also observed for step count. The partial Eta squared values are greater than .01, which represent a moderate effect (Cohen, 1977). The inclusion of BMI as a covariate revealed no significant main effect on activity count or on step count.

There were no significant main effects for gender, DCD, or a DCD groups by gender interaction for AEE. For the PQ there was a significant main effect for DCD Groups. Children with DCD ($M = 12.76$, $SD = 4.9$) and DCD-ADHD ($M = 12.92$, $SD = 6.7$) reported themselves as participating less in organized sports and free-play activities than their typically developing peers ($M = 18.22$, $SD = 6.3$). The inclusion of BMI as a covariate revealed no significant main effect on PQ.

In order to better appreciate the nature of the interaction between groups and gender, we stratified the sample by gender, and ran separate ANOVAs for both step count and activity count (Table 4.2). We also conducted two-tailed t-tests for gender differences within groups for each of the PA measures. We then

graphed the association between gender, group and each outcome (See Figures 4.1 and 4.2). Paying attention to group differences stratified by gender first, there are some interesting differences to be noted.

4.4.1 Activity count

In Figure 4.1, the results for gender, group and activity count are presented. Among males, activity count is highest in the control group, and lowest in both the DCD and DCD-ADHD groups. The male control group reported significantly higher activity counts ($M=239218$, $SD=80610$) than males with DCD ($M=185129$, $SD=66931$) or DCD-ADHD ($M=173661$, $SD=33450$) ($F(2,56)= 5.36$, $p< .01$). Post-hoc comparisons were significant between the boys in the control and DCD groups ($p=.03$), and the control group and DCD-ADHD ($p=.02$). For girls, there appears to be no difference in activity count ($p>.05$) between the DCD, DCD-ADHD, and control groups. Turning to within group comparisons, among children with DCD and DCD-ADHD, there does not appear to be any differences in activity count between boys and girls, however among controls, activity counts are much lower for girls ($M=162,854$, $SD=50,934$), than boys ($M=239,218$, $SD=80,611$) ($p<0.01$).

Table 4.2 ANCOVA for physical activity outcome measures by group (DCD and DCD-ADHD)

| Indices | DCD Groups' | $p \eta^2$ | Gender | $p \eta^2$ | BMI (kg/m ²) | $p \eta^2$ | DCD Groups' *Gender Interaction | $p \eta^2$ |
|----------------|---------------------|------------|------------------|------------|--------------------------|------------|---------------------------------|------------|
| Activity Count | $F(2,92)=1.34$ | .268 | $F(1,92)=4.92^*$ | .051 | $F(1,92)=.60$ | .007 | $F(2,92)=3.11^*$ | .063 |
| Step Count | $F(2,92)=.72$ | .268 | $F(1,92)=4.43^*$ | .046 | $F(1,92)=.22$ | .002 | $F(2,92)=4.92^{**}$ | .097 |
| PQ | $F(2,79)=5.55^{**}$ | .123 | $F(1,79)=.80$ | .010 | $F(1,79)=.69$ | .010 | $F(2,79)=.61$ | .015 |
| AEE | $F(2,92)=.74$ | .016 | $F(1,92)=2.42$ | .026 | -- | -- | $F(2,92)=.59$ | .013 |

$p \eta^2$ = Partial Eta squared, *** $p < .001$, ** $p < .01$; * $p < .05$,

-- Weight is included in AEE equation; therefore BMI not a covariate.

4.4.2 Step Count

In Figure 4.2, the results for gender, group and step count are presented. Among females, step count is highest in the DCD-ADHD group, and lowest in both the DCD and control groups. The female DCD-ADHD group reported significantly higher step counts ($M=9900.0$, $SD=4834$) than, females in the control group ($M=6577.9$, $SD=25760$) ($F(2,37)=3.55$, $p=.04$), however the DCD group was not significantly different from either the DCD-ADHD or control groups. Post-hoc comparisons were significant between girls in the control and DCD-ADHD groups ($p<.03$). Turning to within group comparisons, among children with DCD and DCD-ADHD, there does not appear to be any differences in step count between

boys and girls, however among controls, boys had significantly more step counts (M=11,409.4, SD=4,704), than girls (M= 6,577.9, SD=2,576) ($p<.01$).

Table 4.3 Physical activity measures by group

| | DCD | DCD-ADHD | Controls |
|------------------------|---------------|---------------|----------------|
| Step count (#) | | | |
| Males | 8795.2±3638 | 8658.2±2934 | 11409.4±4704† |
| Females | 7292.5±2317 | 9900.0±4834* | 6577.9±2576 |
| Activity count (units) | | | |
| Males | 185129±66931* | 173661±33450* | 239218±80611†† |
| Females | 172527±50372 | 170821±72488 | 162854±50934 |
| AEE (kilocal/day) | | | |
| Males | 718.5±329 | 623.9±263 | 644.4±169†† |
| Females | 596.2±198 | 627.7±182 | 540.3±162 |
| PQ Total | | | |
| Males | 11.09±4.1** | 12.42±6.1* | 18.42±7.1 |
| Females | 14.60±5.2 | 13.42±7.4 | 17.94±5.2 |

Note: ** $p<.01$, * $p<.05$ between DCD and controls and between DCD-ADHD and controls

†† $p<.01$, † $p<.05$ within group by gender

Figure 4.1 Mean scores for activity count by gender and group

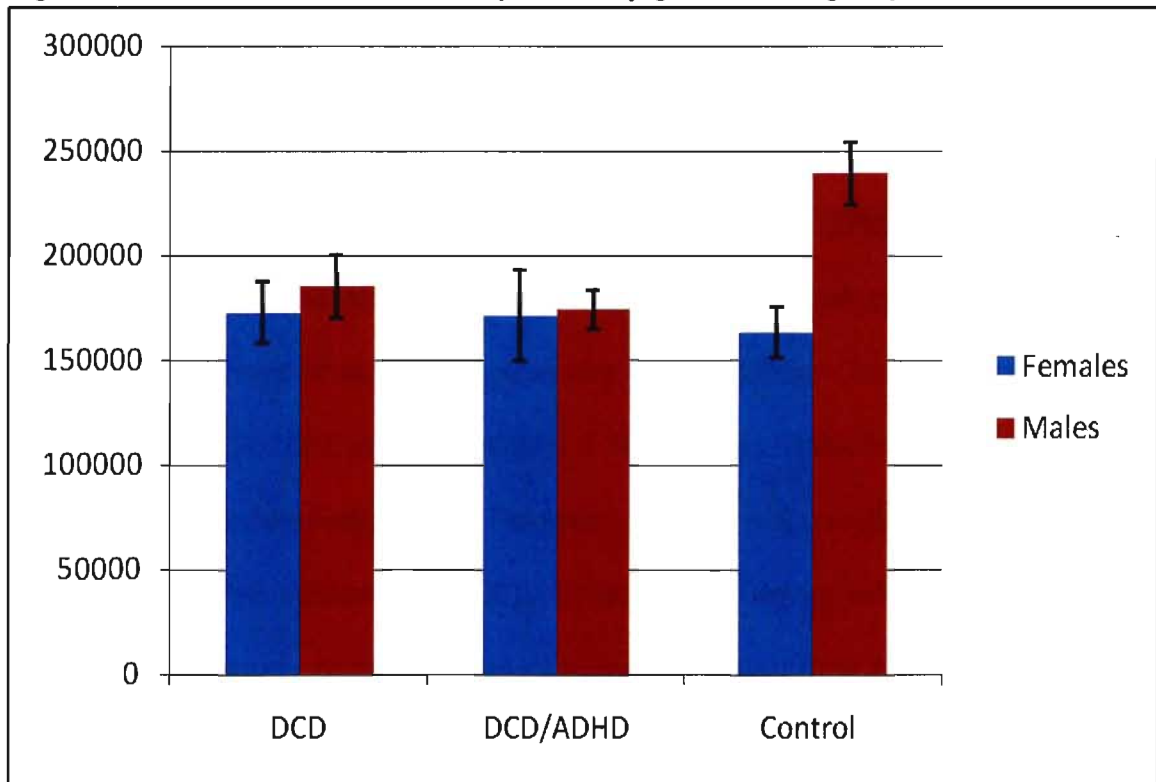
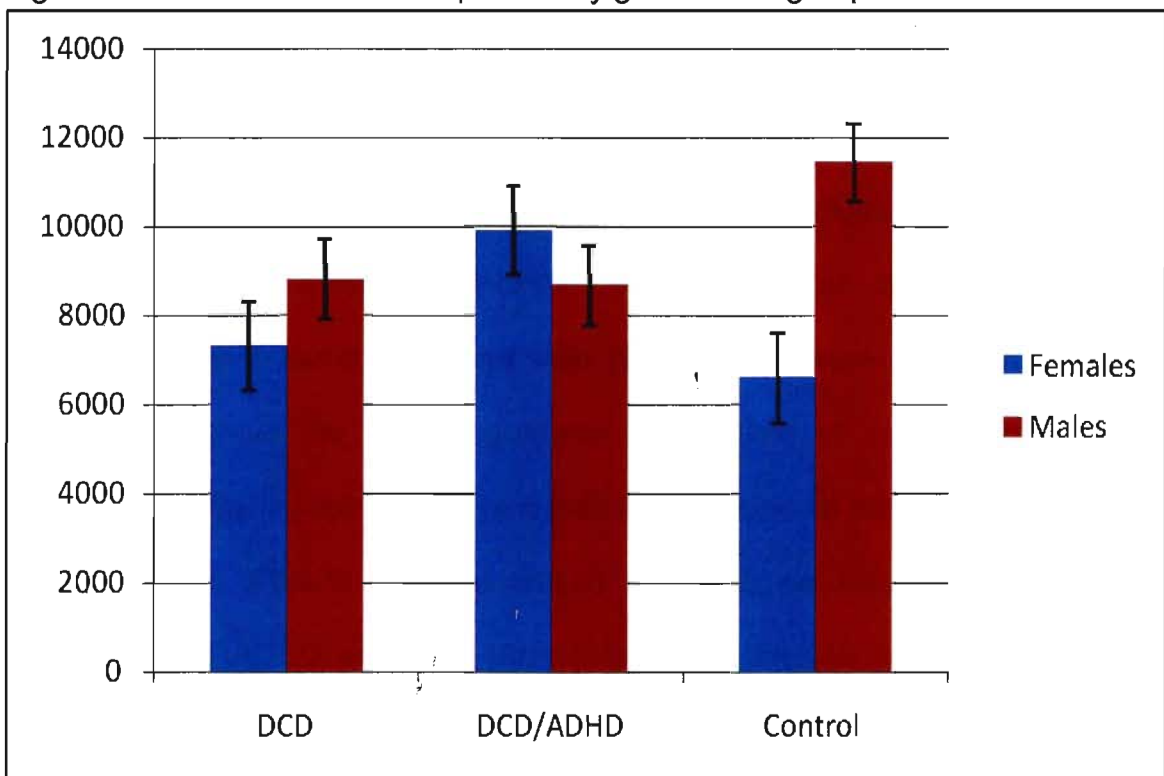


Figure 4.2 Mean scores for step count by gender and group



CHAPTER 5 - DISCUSSION

5.1 Introduction

In the past decade, numerous studies have examined differences in physical activity between children with DCD and those without motor coordination challenges (Cairney et al., 2005b; Cairney et al., 2005c; Cairney et al., 2006b; Cairney et al., 2007b; Causgrove-Dunn & Romanow, 1996; Haga, 2008; Hay et al., 2004; Hay & Missiuna, 1998; Poulsen, Ziviani, & Cuskelly, 2008; Schott, et al., 2007; Smyth & Anderson, 2000). In general, children with DCD report less participation in sports or other forms of active play than their typically developing peers (Cairney et al., 2005b; Faught et al., 2005; Fisher et al., 2005; Hay et al., 2004; Okely et al., 2001), and results from the PQ support this finding within our sample. To date however, there has been no published research that has examined the physical activity patterns of children with DCD co-morbid with ADHD, which is typically found in approximately half the children with DCD. This is a significant gap in the literature as nearly half the children with DCD in our study demonstrate characteristics of ADHD (Gillberg et al., 2004). Porrino and colleagues (1983) found that boys with hyperactivity were more active than controls throughout the week regardless of the time of day. Dane (2000) supported this finding in boys and girls with ADHD using an actigraph to measure physical activity. This is sufficient reason to investigate whether children with both DCD and ADHD are more physically active than those with DCD only. Whether or not the influence of hyperactivity in children with DCD-ADHD might

override the tendency for children with DCD to be physically inactive is not known, nor is the consequences of hyperactivity in the presence of poor motor coordination.

The primary objective of the study was to examine whether there are differences in PA in children with DCD, those with co-morbid DCD and ADHD, and healthy controls. A second objective was to determine if gender moderated the association between groups and PA. This chapter will discuss the results for both objectives and draw parallels where possible in the context of relevant and existing epidemiologic work.

5.2 Gender and physical activity controversy

Our study found that the differences in the PA levels between healthy boys and girls as measured by the accelerometer; AEE, step counts, and activity counts were all higher for boys which is consistent with gender differences found in the literature (Hay, 1992; Klentrou et al., 2003). This result is not as clear in boys and girls with DCD, especially in the context of ADHD. We were presented with two somewhat contradictory gender effects, both of which stem from accelerometer measurements. The greater step count in females with hyperactivity (DCD-ADHD) supports our original hypothesis that children with DCD-ADHD are more physically active than children with DCD or their healthy controls and support the findings of Dane (2000). Conversely, males with DCD and comorbid DCD-ADHD were significantly less active than their healthy controls. The absence of a significantly higher activity count for boys with co-

morbid DCD and ADHD is inconsistent with the findings of Porrino and colleagues (1983) and does not support our hypothesis. However, it should be noted that Porrino et al. (1983) only compared boys with hyperactivity to control subjects and did not consider the impact of clumsiness. In the present study, the poor motor coordination associated with DCD may have detrimental effect on activity among boys, but not among girls co-morbid with DCD and ADHD. Healthy girls were no more active than DCD girls. Thus, while DCD-ADHD girls moved more than other girls, they were no more physically active overall. There is no evidence in the literature to aid in understanding this gender difference. Furthermore, we are not able to explain why the PA measures were significant for step count in only the females and for activity count solely in males. It may be that hyperactive girls express their hyperactivity by moving about more than their peers and as this physical activity requires minimal motor skill was not diminished by DCD. For boys co-morbid with DCD and ADHD, their hyperactivity may be expressed in a greater degree of upper body movements which would not be captured by step counts or whole body activity counts. They could be 'hyperactive' even if withdrawing from active play with their peers due to motoric incompetence. At this juncture, our interpretations remain speculative and our findings remain unresolved in explain these gender differences. Further research is needed in this area to examine gender physical activity patterns relative to DCD, co-morbid DCD and ADHD and healthy controls.

5.3 Interpreting the findings

In light of the conflicting physical activity results and a possible gender-measurement issue (step count versus activity count), we have attempted to provide an interpretation of the negative interaction found in the physical activity behavior of males with DCD and DCD-ADHD that did not support our original hypothesis. Contrary to the hypothesis that children with DCD-ADHD would demonstrate a different level of physical activity behavior than their DCD counterparts and healthy controls, the study's findings demonstrated that hyperactivity had no influence on reported or measured physical activity within the context of DCD in boys. Perhaps the absence of a difference can be attributed to a need to measure movement in these children in a different way. Self-reported participation in physical activity may not be appropriate or sensitive enough in measuring hyperactivity that is indicative of children with ADHD. While accelerometry may be more sensitive in measuring actual movement, we were expecting boys with DCD-ADHD to demonstrate a greater step or activity count compared to children with only DCD, as was seen in the step count of girls with DCD-ADHD. Failing to find this, we need to further understand what constitutes hyperactive behavior expressed by boys with ADHD. We speculate the physical activity expressed by boys with DCD-ADHD may be more fidgeting and shifting while seated, rather than stepping about, running and climbing. The nature of this activity would have lent itself to both step and activity counts as detected on an accelerometer similar to those of the DCD only group.

Activity energy expenditure was lower for the healthy controls when compared to the DCD and DCD-ADHD groups, although not significant. Activity energy expenditure is an estimator that arises from the accelerometer and the energy expenditure is influenced by body weight and economy of movement, which are factors in AEE during physical activity (Ekelund et al., 2002). Therefore, energy expenditure is a poor indicator of the actual amount or duration of physical activity (Schutz, Weinsier, & Hunter, 2001). The average weight of children with DCD and DCD-ADHD was significantly greater than control subjects in our study. Increased weight in these two groups would have skewed the values seen in AEE compared to non-DCD children. Two subjects of differing weight performing the same movement will expend different levels of energy. The heavier subject requires more energy to move their greater body mass the same distance. Our finding that children with DCD have higher body weight compared to healthy controls is consistent with other studies of DCD (Cairney et al., 2007a; Cairney et al., 2007b; Faght, et al., 2005) and ADHD (Cortese, 2008). Nevertheless, it could be speculated that if boys with DCD and DCD-ADHD had achieved similar levels of physical activity as their non-DCD peers, their energy expenditure would be appreciably greater than the AEE reported in our study as a result of their increased weight. To our knowledge, no literature has demonstrated that children with DCD-ADHD expend comparable levels of energy as a function of physical activity compared to healthy control children. Poulsen et al. (2008) reported significantly lower mean energy expenditure in boys with DCD compared to their non-DCD counterparts.

However, they did not report weight, making it impossible to explain differences in energy expenditure due to body weight.

One could also consider the impact of uncoordinated movement that is undertaken by children with DCD in explaining comparable levels of AEE. The inefficient movement characteristic of children with DCD and DCD-ADHD in performing gross motor activity, such as gait, could require greater energy expenditure than in coordinated children. Although economy of movement was not measured in our study, compensatory mechanics similar to those found in patients suffering from disabilities in gait, such as stroke (Thijssen et al., 2007), poliomyelitis (Luna-Reyes et al., 1988; Hwang et al., 2008), or in the elderly (Malatesta et al., 2003) may be a plausible explanation for the increased expended energy required to accomplish the lower activity count and self-reported physical activity by children with DCD and DCD-ADHD. A step fluently taken results in less force/acceleration than does one taken less smoothly and therefore has a lesser effect on an accelerometer and its energy calculations. Normal walking requires sufficient muscular strength, joint movement and coordination of the central nervous system. Deficiency of any of these capabilities can affect human gait patterns (Jessica & James, 1994). Hwang & colleagues (2008) examined the efficiency of knee orthoses in poliomyelitis patients on energy consumption during uncoordinated walking. Increased stability from the knee orthosis resulted in less energy consumption (33%) during gait analysis. Although not in the same context, it is possible that similar types of uncoordinated movement found in children with DCD could require greater total

energy expenditure during daily physical activity compared to children with normal coordination. Pitcher and colleagues (2003) measured motor coordination in boys with ADHD and controls using the M-ABC. Although the study did not identify children with DCD, they found that, compared to their peers, boys with ADHD demonstrated diminished fine motor skills that may be attributed to their poor motor ability (Pitcher et al., 2003).

The data in our study support that girls with DCD-ADHD are more active than DCD or their healthy controls. Conversely, the data show that boys with DCD-ADHD are equally as active as boys with DCD, and that boys in both these groups are significantly less active than their healthy peers.

5.4 Study limitations

There are two significant limitations of this study that must be identified. The ability to measure physical activity, particularly in children is difficult. We opted to implement both self report and accelerometry methods, and both as described earlier have weaknesses. The difficulties of self-report – both recall accuracy and susceptibility to bias - are well established. Accelerometers are limited in that they do not capture all movements all the time and are prone to mechanical malfunction. In our study, 11 subjects' accelerometer data was unusable, four due to technically faulty data and seven due to insufficient time worn. The differences in the number of subjects in each group that provided accelerometer data may also help explain our unexpected results. The PQ provides a longer-term picture, while the Actical accelerometer provides an immediate measure of

PA and so comparisons between the two are limited. However the use of multiple methods for the evaluation of activity is considered advantageous since physical activity is not a unitary construct.

Another limitation is the use of the Connors Parent Rating Scale (CPRS-R) used to identify children with ADHD. We opted for the parents to answer questions about their child. Typically, the process of interpreting the CPRS-R tool when used to diagnose ADHD requires the integration of information from multiple sources, including parents, teachers and expert physicians. In this study, only the parents' perspective was obtained and therefore our identification of children with ADHD should be considered preliminary and not a diagnosis. Furthermore, we were not certain that the parent most familiar with their child actually completed the CPRS-R. As a result, the parent may not have reported the child's behaviors as accurately as possible, leading to an under or over-estimation of hyperactivity.

5.5 Implications of study findings and future research

Future research is needed to examine if differences exist in accelerated movement of boys and girls, and how these difference influence measured physical activity. Furthermore, it has not been ascertained whether children with DCD-ADHD are similar to that of children with DCD in body composition, aerobic fitness level, and risk of developing associated health conditions such as obesity, cardiovascular disease (Faught et al., 2005; Cairney et al, 2005a; Hay et al, 2003), and diabetes. Prospective studies should also attempt to incorporate

accelerometer measurements whereby encouraging subjects to wear the device completely for a period of one week, with exceptions for bathing or for safety reasons (e.g., body contact sports). Wearing the accelerometer for longer periods of time may provide a better estimation of physical activity. Finally, the diminished physical activity found in children with DCD and girls (compared to boys) suggests the need for a more concerted effort to increase the participation of these children in casual active play which optimizes in activities of varying degrees of difficulty within a non-competitive environment. These specific pediatric cohorts may become more involved in physical activity if parents and educators provide programming that contributes to enhancing their self confidence during physical activity (play).

5.6 Conclusion

We concluded that hyperactivity as expressed among girls with DCD appears to override the hypoactive behavior typically found in clumsy children. Conversely, the expression of hyperactivity among boys with DCD does not translate into increased whole-body movements. In fact, the hypoactivity typically observed in children with DCD appears equally present in DCD-ADHD boys. As this is an initial investigation of the differences in PA between children with DCD and DCD-ADHD we have little precedent for comparison. The apparent gender differences of the influence of ADHD on PA are intriguing and worthy of further investigation.

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APPENDICES

APPENDIX 1 – REB Letter of Approval

DATE: January 10, 2008

FROM: Michelle McGinn, Chair
Research Ethics Board (REB)

TO: Brent FAUGHT, CHSC
John Hay,
John Cairney

FILE: 07-106 FAUGHT

TITLE: Establishing the Health Profile of Children with Motor Coordination Challenges

The Brock University Research Ethics Board has reviewed the above research proposal.

DECISION: Accepted as clarified

This project has received ethics clearance for the period of January 10, 2008 to December 30, 2011 subject to full REB ratification at the Research Ethics Board's next scheduled meeting. The clearance period may be extended upon request. ***The study may now proceed.***

Please note that the Research Ethics Board (REB) requires that you adhere to the protocol as last reviewed and cleared by the REB. During the course of research no deviations from, or changes to, the protocol, recruitment, or consent form may be initiated without prior written clearance from the REB. The Board must provide clearance for any modifications before they can be implemented. If you wish to modify your research project, please refer to <http://www.brocku.ca/researchservices/forms> to complete the appropriate form Revision or Modification to an Ongoing Application.

Adverse or unexpected events must be reported to the REB as soon as possible with an indication of how these events affect, in the view of the Principal Investigator, the safety of the participants and the continuation of the protocol.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of any research protocols.

The Tri-Council Policy Statement requires that ongoing research be monitored. A Final Report is required for all projects upon completion of the project. Researchers with projects lasting more than one year are required to submit a Continuing Review Report annually. The Office of Research Services will contact you when this form *Continuing Review/Final Report* is required.

Please quote your REB file number on all future correspondence.

MM/kw

Office of Research Ethics, MC D250A
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<http://www.brocku.ca/researchservices/ethics/humanethics/>

APPENDIX 2 – Sample Size Estimation

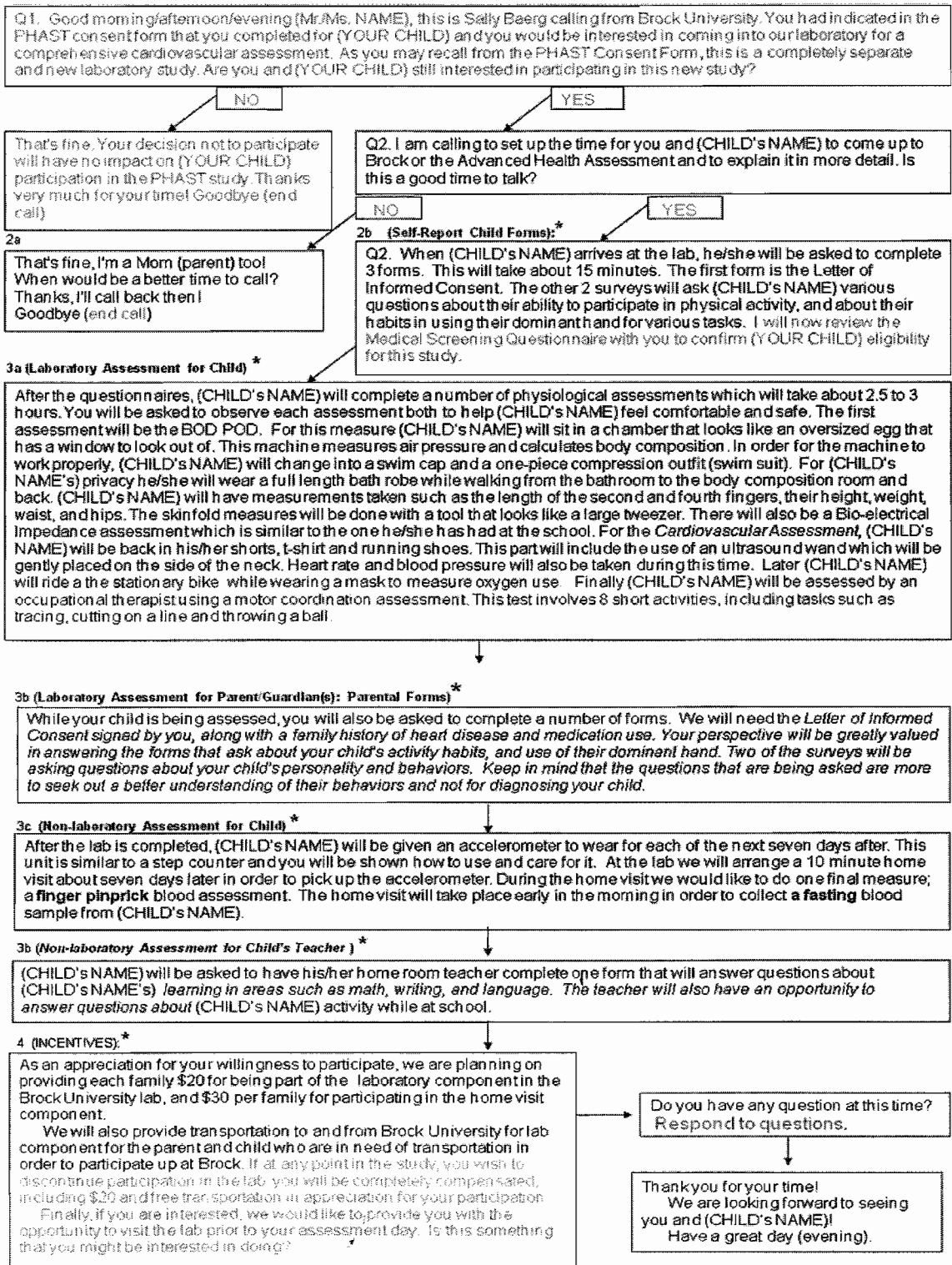
The following sample size formula has been selected to provide valid inferences from a cohort of children suspected of developmental coordination disorder participating in the PHAST project. The sample size formula used for calculating n is:

$$\frac{(N * p * q) * (Z_{\alpha})^2}{(p * q) * (Z_{\alpha})^2 + (N - 1) * (\text{error})^2}$$

The present study intended to accept a level of 95% confidence (Z_{α}) and maximum error of 10%. The table below represents a 95% confidence level and degrees of error ranging from 5 to 10%. Sample size estimation was based on an initial population size of 2260 accessible subjects, which represented the approximate number of children participating in the PHAST project. Expected proportions ($p * q$) { p = proportion of +DCD; q = proportion of -DCD} for period prevalence (0.051; 95%CI, 0.035-0.074) confirmed by the BOTMP-SF served as a conservative estimation of sample size (Cairney et al., 2005a).

| Initial Population (N=2260) | Expected Proportion ($p * q$) | Percent Confidence (Z_{α}) | Percent Error (%) | Sample Size (n) |
|--------------------------------|------------------------------------|--|----------------------|------------------------|
| Prevalence (0.051) | 0.0484 | 95% | 10 | 18 |
| | | | 9 | 22 |
| | | | 8 | 29 |
| | | | 7 | 37 |
| | | | 6 | 51 |
| | | | 5 | 72 |

APPENDIX 3 – PHAST Telephone Script for Laboratory Assessment



* Note: Indicates that each section will end with a chance for parents to ask questions. Order of script may not play out in this particular order.

APPENDIX 4 – Child Letter of Informed Assent

Principal Investigators: Dr. John A. Hay, Brock University
Dr. John Cairney, University of Toronto and Brock University
Dr. Brent E. Faught, Brock University

Dear Parent and Child:

Thank you for your interest in our study. Please read the following information together. If you both feel comfortable and willing to participate in the tests described below, please check the boxes at the end of this consent form indicating child assent and parent consent.

Purpose: The purpose of this study is to look at healthy growth and development of children for the next three years.

Procedures: This assessment will take approximately 2.5 to 3 hours long and is divided into three parts. We thank you for participating. As promised, we have agreed to provide transportation for you to and from Brock University as well as \$50 for your family's participation in this study. Your participation is voluntary and you are free to withdraw from this study at any time without penalty from Brock University. Further, you are under no obligation to answer any or all questions or to participate in any aspect of this project. If you wish to stop participating in this study at any time, you and your parent will still receive free transportation from us as well as \$50 for your participation in the laboratory. Each part is described below.

PART I

This part of the study will be conducted in our laboratory at Brock University and requires 2.5 to 3 hours of your time. First, we would like you to complete the following forms, which will take about 10 minutes.

1. Medical Screening Questionnaire
2. Edinburgh Survey – Handedness Questionnaire

Next, we would like to complete a number of physical assessments on your child with the parent/guardian present. These assessments include:

1. **Body composition:**
 - a. Height and weight will be measured using a dual purpose stadiometer.
 - b. 9 skinfold sites using painless pinch calipers. (It does not hurt).
 - c. Measure around the waist and hip using a flexible tape measure.
 - d. Bioelectric impedance analysis requires your child to stand on a weight scale and grasp handles. An electrical impulse travels from your child's hands to their feet. The impulse cannot be felt and causes no harm.
 - e. Lengths of your child's ring and index fingers.
 - f. Body muscle and fat weight will be measured while your child sits in the BOD POD chamber. If your child expressing previous or current anxiety for confined spaces, they will not be allowed to participate in this portion of the study. The BOD POD incorporates a built in window on the front of the chamber in the event of a claustrophobic event or for communication purposes as well as a safety latch on the inside of the chamber for the subject to voluntarily exit on their own. During this 5-minute assessment, your child will be asked to relax and breathe normally.
2. **Cardiovascular health measures:** The carotid ultrasound method will be performed using a probe and pen like-devices. Heart rate will be measured using sensors placed on the skin of your child's chest. These sensors are used to detect the electrical activity

generated by the heart and are not used to transmit electrical signals into their body from the heart rate monitor. Blood pressure is monitored using an automated arm cuff system that is similar to the method used in a doctor's office. A cuff is wrapped around the upper arm and is inflated then deflated. No risk is involved.

3. **Movement ABC² assessment:** This motor coordination assessment involving 8 short activities, including tasks such as tracing, cutting on a line and throwing a ball.
4. **Physical fitness assessment:** This assessment uses a bicycle to measure the maximum amount of heavy exercise. The bicycle tension will gradually get more difficult to pedal. A mask over the mouth and nose will be used to collect oxygen and carbon dioxide. The assessment will be finished when your child decides. One of the common risks of these kinds of assessments is the brief sensation of exhaustion. At the end of the assessment, your child will be asked to continue to pedal the bicycle at a very easy level until this sensation goes away. The risk of serious illness or death is extremely rare and is reduced by completing the medical screening questionnaire before the assessment and the continuous monitoring we will perform during the assessment.
5. **Accelerometer assessment:** This assessment will require your child to wear a small box the size of a smaller pager clipped onto their pant waist. The accelerometer is designed to measure activity movement that your child performs. We wish for your child to wear the accelerometer from the time they wake up, until the go to bed at night for 7 days. We also ask that the parent complete the Habitual Activity Estimation Scale and our Activity Log. There is no risk associated with this assessment. We will make arrangements to pick the accelerometer unit at your home.

PART II

The second part of the study would take place approximately 7 days from now at your home. We would come in the morning (before your child has breakfast) and it will only take about 10 minutes. We wish to collect a sample of your child's blood using a finger prick technique. The middle finger of your child's non-dominant hand (e.g. if they are right handed, we will use the middle finger of their left hand) will be pricked so two drops of blood can be sampled. Your child will feel a small prick, but will not feel any pain or discomfort for the remainder of the assessment. The tip of that finger may feel sensitive and a little bit sore for about a day. It is important to keep the site clean and covered with an adhesive bandage until it is healed to reduce the risk of infection. We will also use this moment to pick up the accelerometer that you will have had for the past week.

PART III

For this part of the study we would like you to allow your child's homeroom teacher complete a survey on your child's combined listening, speaking, reading, writing, mathematics and reasoning skills. The name of this survey is the Learning Disabilities Diagnostic Inventory. Despite the name of this survey, we are not looking to diagnose any disabilities in your child's learning ability, nor are the teacher expected to provide a learning disabilities' diagnosis. We simply wish to see how able your child is while learning at school. The results of this assessment will not be shared with your child's school.

Participation and Withdrawal: Your child's participation is voluntary and they are free to withdraw from this study at any time without penalty from Brock University. Further, your child is not required to answer any or all questions or to participate in any aspect of this project.

Confidentiality: All personal data will be kept strictly confidential and all information will be coded so that your child is not associated with their answers. Only the researchers named above will have access to the complete data. Any information we receive will be entered immediately

into computer records using a code number with no name attached. It is our intent to continue to publish the results of this research in scientific journals. Again, no personal information will be identified or be possible within any publication.

Information: This study has been reviewed and approved by the Brock University Research Ethics Board, (File#: 07-106) Research Services, Brock University, Room C315 - 905-688-5550 (Ext. 4315). We greatly appreciate your co-operation. If you would like to receive more information about the study, please contact **Dr. Brent E. Faught** at 905-688-5550, (Ext. 3586). If you are willing to grant permission to participate in this study, please complete the consent form below.

Thanks for your help!

Brent E. Faught, Ph.D.

John A. Hay, Ph.D.

John Cairney, Ph.D.

PARENT CONSENT FORM

I have read and understand the above explanation of the purpose and procedures of the project. My questions have been answered to my satisfaction.

- ☐ I give permission for my child to participate in **Part I** of the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.
- ☐ As the participating child, I wish to participate in **Part I** of the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.
- ☐ I give permission for my child to participate in **Part II** of the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.
- ☐ As the participating child, I wish to participate in **Part II** of the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.
- ☐ I give permission for my child to participate in **Part III** of the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.
- ☐ As the participating child, I wish to participate in **Part III** of the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.

OR

- ☐ I do **NOT** give permission for my child to participate in the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.
- ☐ As the participating child, I do **NOT** wish to participate in the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.

Signature of Parent/Guardian: _____ Date: _____

Signature of Student: _____ Date: _____

APPENDIX 5 – Parent Letter of Informed Consent

Principal Investigators: Dr. John A. Hay, Brock University
Dr. John Cairney, University of Toronto and Brock University
Dr. Brent E. Faught, Brock University

Dear Parent/Guardian:

Purpose: The purpose of this study is to investigate healthy growth and development and its association with the physical activity of children for the next three years.

Procedures: We are requesting that you complete five forms as they relate to you and _____ (child's name). These forms will take approximately 40 minutes to complete.

Participation and Withdrawal: As a condition of your participation, we have agreed to provide transportation for you and your child to and from Brock University as well as \$50 for your family's participation in this study. Your participation is voluntary and you are free to withdraw from this study at any time without recourse from Brock University. Further, you are under no obligation to answer any or all questions or to participate in any aspect of this project. If you wish to discontinue participation in this study at any time, you and your child will still receive complementary transportation as well as \$50 for your participation in the study.

Confidentiality: All personal data will be kept strictly confidential and all information will be coded so that you are not associated with your answers. Only the researchers named above will have access to the complete data. Any information we receive will be entered immediately into computer records using a code number with no name attached. It is our intent to continue to publish the results of this research in scientific journals. Again, no personal information will be identified or be possible within any publication.

Information: This study has been reviewed and approved by the Brock University Research Ethics Board, (File#: 07-106) Research Services, Brock University, Room C315 - 905-688-5550 (Ext. 4315). We greatly appreciate your co-operation. If you would like to receive more information about the study, please contact **Dr. Brent E. Faught** at 905-688-5550, (Ext. 3586). If you are willing to grant permission to participate in this study, please complete the consent form below.

Thanks for your help!

Brent E. Faught, Ph.D.

John A. Hay, Ph.D.

John Cairney, Ph.D.

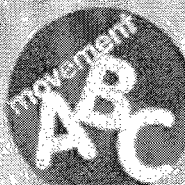
PARENT CONSENT FORM

I have read and understand the above explanation of the purpose and procedures of the project. My questions have been answered to my satisfaction.

- ☐ I wish to participate for the next three years in this Brock University study conducted by Dr. Brent E. Faught, Dr. John Hay and Dr. John Cairney.
- ☐ I do **NOT** wish to participate in this Brock University study conducted by Dr. Brent E. Faught, Dr. John Hay and Dr. John Cairney.

Signature of Parent/Guardian: _____ Date: _____

APPENDIX 6 – Movement Assessment Battery for Children, Version 2



Movement Assessment Battery for Children – 2

Test Record Form Age Band 3 (11-16 years)

| | | | |
|-------------------------------|-------------|-------------------------|------------|
| Name: _____ | | Gender: M / F _____ | |
| Home address: _____ | | | |
| School: _____ | | Class/Year/Grade: _____ | |
| Assessed by: _____ | | | |
| Referral source: _____ | | | |
| Preferred writing hand: _____ | Year: _____ | Month: _____ | Day: _____ |
| Date tested: _____ | | | |
| State of birth: _____ | | | |
| Chronological age: _____ | | | |

Movement ABC 2
 Checked completed: _____

Item Scores and Equivalent Standard Scores

| Item code | Name of task | Raw score (best attempt) | Item Standard Score |
|--|-------------------------------------|--------------------------|---------------------|
| MD 1* | Turning Page performed hand | | |
| MD 2 | Turning Page non-preferred hand | | |
| MD 3 | Triangles with Right and Left | | |
| MD 4 | Catching Ball 2 | | |
| ABC 1 | Catching with one hand - best hand | | |
| ABC 2 | Catching with one hand - other hand | | |
| ABC 3 | Throwing at Visual Target | | |
| Bal 1* | Top of Head Balance | | |
| Bal 2 | Waist to Floor Balance | | |
| Bal 3 | Agility Balance (Left leg) | | |
| | Agility Balance (Right leg) | | |
| Total Test Score Sum of 6 Item standard scores | | | |

Three Component Scores*

Manual Dexterity* MD 1 + MD 2 + MD 3

| Component score | Standard Score | Percentile Rank |
|-----------------|----------------|-----------------|
| | | |

Arm & Catching* ABC 1 + ABC 2

| Component score | Standard Score | Percentile Rank |
|-----------------|----------------|-----------------|
| | | |

Balancing* Bal 1 + Bal 2 + Bal 3

| Component score | Standard Score | Percentile Rank |
|-----------------|----------------|-----------------|
| | | |

*In each case sum the three standard scores.

| Total Test Score | Standard Score | Percentile Rank |
|------------------|----------------|-----------------|
| | | |

*For Balance Post, Catch, and Throw Manual and Ag. Bal. and Ag. Bal. use standard score 1 on each first, add 17 age and 13 age for 2. For Balance Post, Catch, and Throw Manual and Ag. Bal. and Ag. Bal. use standard score 1 on each first, add 17 age and 13 age for 2.

Manual Dexterity 1: TURNING PEGS



Record: Preferred hand: **R** (L should be same as for Drawing Trail). Time taken (sec): **7** for failure.
R for refusal, **I** if inappropriate (note reasons below)

| No. of pegs | Hand | Preferred hand (R) Time taken (sec) for 10 pegs | | | | | | | Non-preferred hand (L) Time taken (sec) for 10 pegs | | | | | | |
|-------------|------|---|------|------|------|------|------|------|---|------|------|------|------|------|------|
| | | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th |
| 10 | | 11.0 | 10.0 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 10.0 | 10.0 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 |
| 20 | | 18.0 | 17.0 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 18.0 | 17.0 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 |

Qualitative observations

Posture/body control

Sitting posture is poor

Holds head too close to task

Holds head at an odd angle

Does not look where manipulating pegs

Does not use pinch grip to pick up pegs

Suggests finger movements in releasing pegs

Does not use the supporting hand to hold board steady

Does not move board with one hand dexterity tasking

Changes hands if pegs both hands available

Hand movements are jerky

Moves constantly/fidgets

Adjustment to task requirements

Makes good use of respect for time

Makes excessive finger when inserting pegs

Is exceptionally slow/does not change speed from start to finish

Does not test for accuracy

Other

Comments

Manual Dexterity 2: TRIANGLE WITH NUTS AND BOLTS



Record: Time taken (sec): **7** for failure, **R** for refusal, **I** if inappropriate (note reasons below)

| No. of bolts | Hand | Preferred hand (R) Time taken (sec) for 10 bolts | | | | | | | Non-preferred hand (L) Time taken (sec) for 10 bolts | | | | | | |
|--------------|------|--|------|------|------|------|------|------|--|------|------|------|------|------|------|
| | | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th |
| 10 | | 11.0 | 10.0 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 10.0 | 10.0 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 |
| 20 | | 18.0 | 17.0 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 18.0 | 17.0 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 |

Qualitative observations

Posture/body control

Sitting posture is poor

Holds materials too close to face

Holds head at an odd angle

Does not look where inserting bolt

Does not use pinch grip to hold nuts and bolts

Finds it difficult to hold bolt with one hand and screw

Not sure with the other

Changes hands if using other

Hand movements are jerky

Moves constantly/fidgets

Adjustment to task requirements

Sometimes misses hole with tip of bolt

Gets involved in the construction sequence

Is exceptionally slow/does not change speed from start to finish

Does not test for accuracy

Other

Comments

Manual Dexterity 3: DRAWING TRAIL 3

Note: R/L/Both: pen to be used

Record: Hand used: R/L/Both; # of errors: # for failure; R for refusal; L for inappropriate (note reasons below)
Number of errors should be counted after testing using scoring criteria provided in Appendix A of the Manual

| Trial | No. of errors |
|---------|---------------|
| Trial 1 | |
| Trial 2 | |



Do not administer a second trial if the child completes the first trial perfectly (i.e. no errors)

Qualitative observations

Posture/body control

Standing posture is poor

Holds head too near paper

Holds head at an odd angle

Does not look at trail

Holds pen with an odd mature grip

Pen is too close to the hand

Holds pen too close to the hand

Does not hold paper still

Changes hands during trial

Moves constantly during

Adjustment to task requirements

Progresses in trial only occasionally

Uses excessive force, especially hand on paper

is abnormally low

Does not take for accuracy

Other

Comments:

Aiming & Catching 1: CATCHING WITH ONE HAND

Record: # times correctly executed (catches); R for refusal; L for inappropriate (note reasons below)

| | | |
|---------------------|-----------|-------|
| Right Hand Practice | 10 Trials | Total |
| Left Hand Practice | 10 Trials | Total |

Qualitative observations

Posture/body control

Standing posture is poor

Does not follow trajectory of ball with eyes

Turns away or moves away as ball approaches

Hands held at a distance from the ball when it is high

Hands held at a distance from the ball when it is low

Arm and hand do not go up and down as high

Fingers close too early or too late

Does extremely poorly with one hand only (usually right hand)

Movements lack fluidity

Adjustment to task requirements

Does not adjust body position for catching

Does not adjust position of feet as necessary

Exposition of these points, flap mouth or lip while

Does not adjust to height of rebound

Does not adjust to direction of rebound

Does not adjust to speed of rebound

Other

Aiming & Catching 2: THROWING AT WALL TARGET

Record: Hand used: R / L / Both; Number of successful throws: R for refusal; I if inappropriate (note reasons below)

Practice: ☐ ☐ ☐ ☐ ☐ 10 Trials: ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Total: _____

Qualitative observations

Posture/body control

- ☐ Balance while throwing is poor
- ☐ Does not keep feet on target
- ☐ Does not follow through with the throwing arm
- ☐ Releases ball too early or too late
- ☐ Changes hands from left to right
- ☐ Movements lack fluency

Adjustment to task requirements

- ☐ Throws are consistently to one side of the target
- ☐ Inconsistently aimed
- ☐ Control of direction is variable
- ☐ Lacks force or throws poorly (too much or too little)
- ☐ Control of force is variable
- ☐ Other: _____

Comments: _____

Balance 1: TWO-BOARD BALANCE



Record: Time: _____ (secs); R for refusal; I if inappropriate (note reasons below)

| | No. of seconds |
|---------|----------------|
| Trial 1 | |
| Trial 2 | |



Do not administer a second trial if the child maintains balance for 30 seconds

Qualitative observations

Posture/body control

- ☐ Body at least moderate
- ☐ Body at least imbalanced
- ☐ Weight evenly on both feet
- ☐ Does not hold head and eyes steady
- ☐ Makes no or few compensatory arm movements
- ☐ No body adjustment

- ☐ Excessive movement of arms and trunk when balance
- ☐ Cannot hold feet in a straight line
- ☐ Other: _____

Comments: _____

Balance 2: WALKING TOE-TO-HEEL BACKWARDS

Record: Number of correctly executed steps from the beginning of the line. Whistle or set line was walked successfully, R for refusal, I if inappropriate (note reasons below):

| | No. of steps | Entire line? |
|---------|--------------|--------------|
| Trial 1 | | YES / NO |
| Trial 2 | | YES / NO |



Do not administer a second trial if the child completes 15 steps OR completes the whole line in fewer than 15 correctly executed steps.

Qualitative observations

Posture/body control

Body appears rigid/tense

Body appears limp/flaccid

Sways widely to try to maintain balance

Does not look behind to check position on track

Does not compensate with arms to maintain balance

Exaggerated arm movements disrupt balance

Is very wobbly when placing feet on line

Adjustments to task requirements

Does too fast for accuracy

Individual movements lack smoothness and fluency

Sequencing of steps is not smooth/feels jerky

Other

Comments

Balance 3: ZIG-ZAG HOPPING

Record: Number of correct hops on line (maximum of 5). R for refusal, I if inappropriate (note reasons below):

| | | No. of hops | | | No. of hops |
|-----------|---------|-------------|----------|---------|-------------|
| Right Leg | Trial 1 | | Left Leg | Trial 1 | |
| | Trial 2 | | | Trial 2 | |



Do not administer a second trial if the child completes 5 perfect hops on the first trial.

Qualitative observations

Posture/body control

Body appears rigid/tense

Body appears limp/flaccid

Sways/wobbling leg held up in front of body

Sways/wobbling leg held out to the side

Does not demonstrate push-off from floor

Arm movements are exaggerated

Does not use arms to assist jump

Stumbles on landing

Does extremely poorly with one leg (asymmetry/stiffing)

Adjustments to task requirements

Does too fast for accuracy

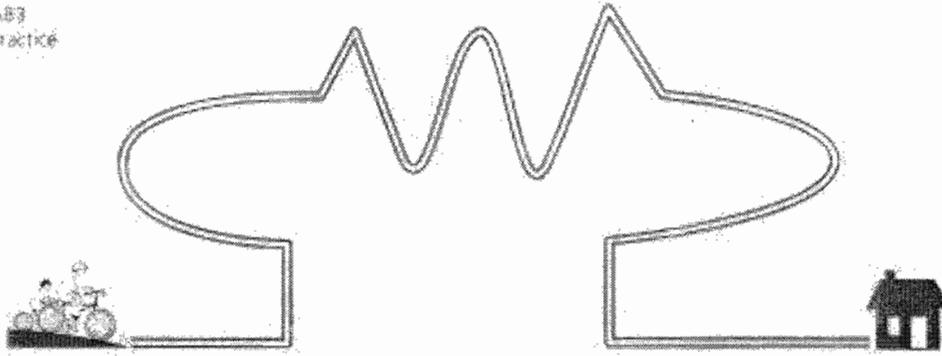
Does not demonstrate forward movement effectively

Does too much effort

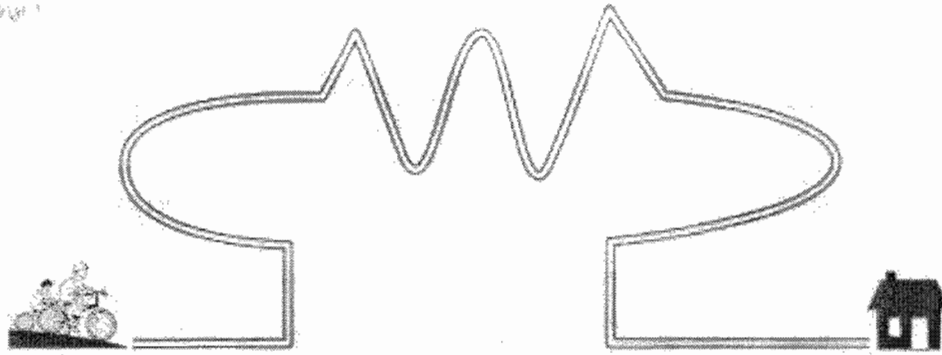
Arm movements are jerky

Other

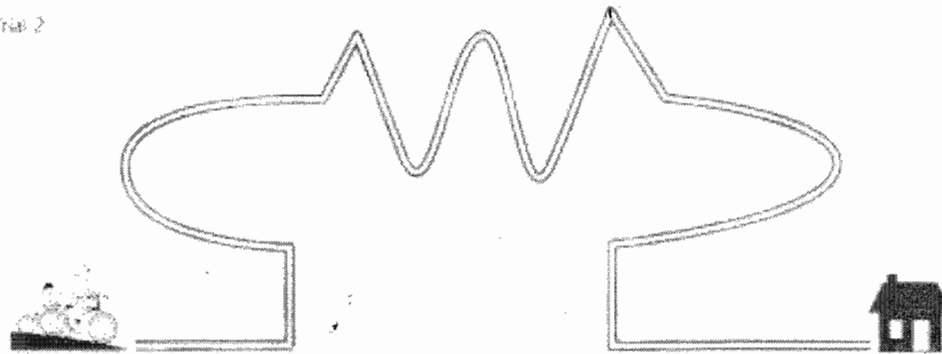
AB3
Practice



Trail 1



Trail 2



NON-MOTOR FACTORS THAT MIGHT AFFECT MOVEMENT

Complete the sections below by noting any features of the child's behaviour during testing that you suspect might have affected his or her motor performance. Readings (with examples) are given as guidelines only. Although negative aspects are given more emphasis, remember to note positive aspects of the child's behaviour.

| | Yes | No |
|---|------------|--------------|
| 1. Disorganised (e.g. scattered clothes, slows up dressing after PE, puts on shoes before socks). | | |
| 2. Hesitant/forgetful (e.g. slow to start complex actions, forgets what to do in the middle of an action sequence). | | |
| 3. Passive (e.g. hard to interest, requires much encouragement to participate). | | |
| 4. Timid (e.g. fearful of activities such as jumping/climbing, constantly asks for assistance). | | |
| 5. Anxious (e.g. trembles, becomes fixated in a stressful situation). | | |
| 6. Impulsive (e.g. starts before instructions are complete, impatient of detail). | | |
| 7. Distractable (e.g. looks away, responds to irrelevant noises). | | |
| 8. Overactive (e.g. squirms and fidgets, moves constantly while listening to instructions, fidgets with clothes). | | |
| 9. Overestimates own ability (e.g. tries to make tasks more difficult, tries to do things too fast). | | |
| 10. Underestimates own ability (e.g. compares of task difficulty, anticipates failure before starting). | | |
| 11. Lacks persistence (e.g. gives up quickly, is easily frustrated). | | |
| 12. Upset by failure (e.g. looks fearful, refuses to try task again). | | |
| 13. Unable to get pleasure from success (e.g. fails to respond to praise). | | |
| Other (please specify): | | |
| Overall, do you think these problems prevent the child from demonstrating his or her true movement capability (please circle) | not at all | a great deal |

PHYSICAL FACTORS THAT MIGHT AFFECT MOVEMENT

| | |
|---|------------------------|
| Anatomical/postural defect: YES/NO | Schedule if possible |
| Visual defect: YES/NO | Hearing defect: YES/NO |
| Judgment of weight: normal/underweight/overweight | |
| Judgment of height: average/much shorter | |
| Other: | |

Table 2a: Brief summary of changes made to AB1 – now covers ages 3 to 6 years

| Task | Movement ABC AB1 | Movement ABC-2 AB1 |
|---------------------|------------------------|-----------------------------|
| Manual Dexterity 1 | Posting Coins | Posting Coins |
| Manual Dexterity 2 | Threading Beads | Threading Beads |
| Manual Dexterity 3 | Bicycle Trail | Drawing Trail 1* |
| Aiming & Catching 1 | Catching Beanbag | Catching Beanbag |
| Aiming & Catching 2 | Rolling Ball into Goal | Throwing Beanbag onto Mat** |
| Balance 1 | One-Leg Balance | One-Leg Balance |
| Balance 2 | Walking Heels Raised | Walking Heels Raised |
| Balance 3 | Jumping over Cord | Jumping on Mats*† |

* Altered item: shape of trail has changed

** New item

Table 2b: Brief summary of changes made to AB2 and AB3 – now labelled AB2 and covers ages 7 to 10 years

| Task | Movement ABC AB2 | Movement ABC AB3 | Movement ABC-2 AB2 |
|---------------------|---------------------------|---------------------------|------------------------------|
| Manual Dexterity 1 | Placing Pegs | Shifting Pegs by Rows | Placing Pegs- |
| Manual Dexterity 2 | Threading Lace | Threading Nuts on Bolt | Threading Lace^ |
| Manual Dexterity 3 | Flower Trail | Flower Trail | Drawing Trail 2* |
| Aiming & Catching 1 | Two-Hand Catch | One-Hand Bounce and Catch | Catching with Two Hands |
| Aiming & Catching 2 | Throwing Beanbag into Box | Throwing Beanbag into Box | Throwing Beanbag onto Mat** |
| Balance 1 | Stork Balance | One-Board Balance | One-Board Balance |
| Balance 2 | Heel-to-Toe Walking | Ball Balance | Walking Heel-to-Toe Forwards |
| Balance 3 | Jumping in Squares | Hopping in Squares | Hopping on Mats+ |

Altered items:

- New start position/layout

^ Lacing board now longer

* Shape of trail has changed

** Mat with target now used instead of box

+ Mats used for this task

Table 2c: Brief summary of changes made to AB4 – now labelled AB3, covering ages 11 to 16

| Task | Movement ABC | Movement ABC-2 |
|---------------------|-------------------------|-------------------------------|
| Manual Dexterity 1 | Turning Pegs | Turning Pegs |
| Manual Dexterity 2 | Cutting-Out Elephant | Triangle with Nuts and Bolts^ |
| Manual Dexterity 3 | Flower Trail | Drawing Trail 3* |
| Aiming & Catching 1 | One-Hand Catch | Catching with One Hand |
| Aiming & Catching 2 | Throwing at Wall Target | Throwing at Wall Target |
| Balance 1 | Two-Board Balance | Two-Board Balance |
| Balance 2 | Walking Backwards | Walking Toe-to-Heel Backwards |
| Balance 3 | Jumping and Clapping | Zig-Zag Hopping^ |

^ New items

* Altered item: Shape of trail has changed

APPENDIX 7 – Accelerometer Log Book

Child's Name _____ Date: _____

Dear Parent,

Thank you very much for allowing your child to be part of this part of the PHAST study! The small device that your child will wear for the next week is called the Actigraph. It is rugged and water- proof and is used to measure activity by counting all the times your child's body moves. There are no buttons to play with or display to look at so you do not have to worry about accidentally changing a setting or losing the stored information. **We would only ask that it be kept away from strong magnets and that it is taken off when your child takes a bath/shower or goes swimming.** Getting wet doesn't harm the Actigraph but the belt it is attached to would get soggy and be uncomfortable to wear!

WHEN YOU ATTACH THE BELT WITH THE ACTIGRAPH PLEASE MAKE SURE THE GREEN SIDE IS FACING UP (CAN BE SEEN BY YOUR CHILD)!!

To help us understand the results we see from the Actigraph we do need your help! **Please mark down on the attached pages the time it was put on in the morning and taken off at night. If the Actigraph was taken off for other reasons please tell us those times and the reason it was taken off.** The following sheets will let you write down those times for us.

The last few pages are a short questionnaire called "Two Days in the Life of My Child" This form takes about 10 minutes to complete. The instructions are quite clear but if you have any questions please do not hesitate to contact us! **This form should be completed the day before we come to pick up the Actigraph.**

Thanks once again for your efforts on our behalf. This is important research and we could not do this without you!

START DATE: _____

Day 1: Time put on in the morning: _____
Time taken off at bed-time: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Day 2: Time put on in the morning: _____
Time taken off at bed-time: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Day 3: Time put on in the morning: _____
Time taken off at bed-time: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Day 4: Time put on in the morning: _____
Time taken off at bed-time: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Day 5: Time put on in the morning: _____
Time taken off at bed-time: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Day 6: Time put on in the morning: _____
Time taken off at bed-time: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Day 7: Time put on in the morning: _____
Time taken off at bed-time: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Thanks! Could you please now complete the form on the next few pages! It does not take long to complete and the information you provide to us will be very helpful!

APPENDIX 8 – Participation Questionnaire

Name: _____ Birth date: ____ / ____ / ____ Age: _____ years
MM DD YY

Grade: _____ Gender: M / F Do you take Physical Education classes? YES / NO

INSTRUCTIONS:

In this survey you will be asked about the activities that you do at school and in your spare time. There are no correct or incorrect answers because this is not a test! Just answer each question as best as you can remember. Please read each question carefully before you answer it. TO ANSWER A QUESTION, JUST CHECK (✓) YOUR ANSWER OR PRINT YOUR ANSWER IN THE SPACE PROVIDED. Only select one answer for each question.

The following is a sample question to practice.

SAMPLE QUESTION

1. How often do you eat an apple?

Never

☐

Once a month

☐

Once a week

☐

Once a day

☐

SECTION 1: FREE TIME ACTIVITIES

This section asks questions about what you do during your free time. Some of the questions will be about recess, some about what you like to do after school, and others will be about what you do on weekends and holidays. Active games mean things like tag or skipping or playing catch.



1. During recess (or spares), do you spend most of your time:

Talk with my friends

☐

Do school work

☐

Play active games

☐

2. After school and before you eat supper, most of the time do you:

Watch
television

☐

Talk with
my friends

☐

Play
active games

☐

Play
video games

☐

Do other things
(Specify below)

3. After supper and before you go to bed, do you spend most of your time:

Watch
television

☐

Talk with
my friends

☐

Read
books

☐

Play
active games

☐

Do other things
(Specify below)

4. On weekends, do you spend most of your time:

Watch
television
☐

Read
☐

Play
active games
☐

Play
video games
☐

Talk with
my friends
☐

Do other things
(Specify below)

5. During your free time, what are the three (3) things you like to do the most?

1. _____ 2. _____ 3. _____

6. During the summer, how often do you ride a bike? (If you answer never, go to Question #8)

Never
☐

Once a month
☐

Once a week
☐

Once a day
☐

All the time
☐

7. When you finish riding your bike, do you usually feel:

Very tired
☐

Tired
☐

A little tired
☐

Not tired at all
☐

8. During the winter, how often do you go ice skating for fun? (If you answer never, go to Question #10)

Never
☐

Once a month
☐

Once a week
☐

Once a day
☐

All the time
☐

9. When you finish ice skating, do you usually feel:

Very tired
☐

Tired
☐

A little tired
☐

Not tired at all
☐

10. How often do you go swimming for fun during the summer? (If you answer never, go to Question #12)

Never
☐

Once a month
☐

Once a week
☐

Once a day
☐

All the time
☐

11. When you have finished swimming, do you usually feel:

Very tired
☐

Tired
☐

A little tired
☐

Not tired at all
☐

12. During the winter, how often do you go cross-country skiing? (If you answer never, go to Question #14)

Never
☐

Once a month
☐

Once a week
☐

Once a day
☐

All the time
☐

13. When you finish cross-country skiing, are you usually:

Very tired
☐

Tired
☐

A little tired
☐

Not tired at all
☐

14. If there are other activities that you do once a week or more, please list them below:

1. _____ 2. _____ 3. _____

15. How often do you watch T.V.?

Every day
☐

Almost every day
☐

Hardly ever
☐

Never
☐

16. How many hours per day do you usually watch T.V.?

0-1
☐

1-2
☐

2-3
☐

3-4
☐

4-5
☐

5 or more
☐

17. How often do you read a book in your free time?

Every day
☐

Almost every day
☐

Hardly ever
☐

Never
☐

18. How many hours a day do you usually read books?

0-1
☐

1-2
☐

2-3
☐

3-4
☐

4-5
☐

5 or more
☐

19. How often do you play video games in your spare time?

Every day
☐

Almost every day
☐

Hardly ever
☐

Never
☐

20. How often do you play active games with your friends after school?

Every day
☐

Almost every day
☐

Hardly ever
☐

Never
☐

21. How often in a week do you play active games with your family?

Every day
☐

Almost every day
☐

Hardly ever
☐

Never
☐

22. When you are playing active games with your friends or family, how often do you play hard enough to breathe heavily or make your heart beat quickly?

Very often
☐

Often
☐

Sometimes
☐

Hardly ever
☐

Never
☐

23. If you have daily or weekly chores at home (cutting grass, shovelling snow, farm chores, paper route), please list them below.

1. _____ 2. _____ 3. _____

24. How do you usually get to school?

Walk
☐

Ride a bike
☐

Take the bus
☐

Get a ride
☐

25. How long does it take you to get to school?

15 minutes
☐

$\frac{1}{2}$ an hour
☐

1 hour or more
☐

26. How many older brothers do you have?

27. How many older sisters do you have?

28. How many younger brothers do you have?

29. How many younger sisters do you have?

SECTION 2: INTRAMURAL GAMES

This section asks questions about what you do during your free time. Some of the questions will be about intramural games. These are games like borden ball or volleyball that you play in teams at (house league) school. Only include active games. These do not include games you play in physical education classes, recesses, or spares. If you haven't played any intramural games this year, check this box ☐ and go directly to SECTION 3.



30. How many different intramural (house-league) activities have you played this school year?

0
☐

1
☐

2
☐

3
☐

4
☐

5 or more
☐

(If you answered 0, please go directly to SECTION 3)

31. During your intramural games, how often did you have to work hard (breathing heavily, sweating, heart beating quickly):

Very often
☐

Often
☐

Sometimes
☐

Hardly ever
☐

Never
☐

32. After playing games in intramurals, are you usually:

Very tired
☐

Tired
☐

A little tired
☐

Not tired at all
☐

33. How many times a week, on average, do you play intramural games?

0
☐

1
☐

2
☐

3
☐

4
☐

5 or more
☐

34. How many hours each week do you think you spend playing intramural games at school?

0
☐

1
☐

2
☐

3
☐

4
☐

5 or more
☐

35. How many of your friends play intramural games?

Most of them
☐

A few of them
☐

None of them
☐

SECTION 3: SCHOOL SPORTS TEAMS

These questions are about school teams that play sports against teams from other schools. If you don't play for any of your school's sports teams, check this box ☐ and go directly to SECTION 4.



36. This school year, how many school sports teams have you belonged to?

0
☐

1
☐

2
☐

3
☐

4
☐

(If you answered 0, please go directly to SECTION 4)

37. After a game or practice, are you usually:

Very tired
☐

Tired
☐

A little tired
☐

Not tired at all
☐

38. During games or practices, did you have to work hard (breathing heavily, sweating, heart beating quickly):

Very often
☐

Often
☐

Sometimes
☐

Hardly ever
☐

Never
☐

39. How many hours per week do you usually spend in practices or games for school sports teams?

0
☐

1
☐

2
☐

3
☐

4
☐

5 or more
☐

40. How many of your friends play on school sports teams?

Most of them
☐

A few of them
☐

None of them
☐

SECTION 4: SPORTS TEAMS OUTSIDE OF SCHOOL

These are teams like hockey, ringette, soccer, and baseball in leagues that are not part of your school. If you haven't played on any sports teams in the last year, check this box ☐ and go directly to SECTION 5.



41. In the last year, how many sports teams have you played on?

- | | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

(If you answered 0, go directly to SECTION 5)

42. How many times a week, on average, do you go to a practice or game?

- | | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

43. How many hours a week, on average, do you think you spend at practices and playing games for sports teams?

- | | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

44. During games and practices, did you have to work hard (breathing heavily, sweating, heart beating quickly):

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Very often | Often | Sometimes | Hardly ever | Never |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

45. After a practice or game, did you usually feel:

- | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|
| Very tired | Tired | A little tired | Not tired at all |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

46. How many of your friends play on sports teams?

- | | | |
|--------------------------|--------------------------|--------------------------|
| Most of them | A few of them | None of them |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

SECTION 5: SPORTS AND DANCE CLUBS

These are clubs like gymnastics, martial arts (karate, judo, etc.), tennis, golf, swimming, horseback riding, and dance (jazz, ballet, and tap). It doesn't include groups like Cubs or Girl Guides or 4H. If you didn't belong to any sports or dance clubs in the last year, check this box ☐ and go directly to SECTION 6



47. In the last year, how many **DANCE** clubs have you belonged to?

- | | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

48. In the last year, how many SPORTS clubs did you belong to?

| | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

49. How many times a week, on average, do you go to a sport or dance competition or practice?

| | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

50. How many hours a week, on average, do you think you spend at sport or dance activities?

| | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

51. During practices or competitions, how often did you have to work hard (breathing heavily, sweating, heart beating quickly):

| | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Very often | Often | Sometimes | Hardly ever | Never |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

52. How tired to you feel after a sport or dance competition or practice?

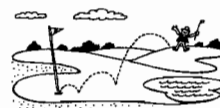
| | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|
| Very tired | Tired | A little tired | Not tired at all |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

53. How many of your friends belong to sports or dance clubs?

| | | |
|--------------------------|--------------------------|--------------------------|
| Most of them | A few of them | None of them |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

SECTION 6: SPORTS AND DANCE LESSONS

This section asks questions about lessons that you took in the last year to learn things like swimming, tennis, golf, or dance. It also includes hockey schools. It doesn't include practices for teams or clubs. If you didn't take any sport or dance lesson in the last year, check this box ☐ and go directly to SECTION 7.



54. In the last year, how many different kinds of sports or dance lessons did you take?

| | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

(If you answered 0, go directly to SECTION 7)

55. How many hours a week, on average, did you spend at sport or dance lessons?

| | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

56. How many times a week did you go to a sport or dance lesson?

0
☐

1
☐

2
☐

3
☐

4
☐

5 or more
☐

57. How many of your friends take sport or dance lessons?

Most of them
☐

A few of them
☐

None of them
☐

58. During your sport or dance lessons, how often did you have to work hard (breathing heavily, sweating, and heart beating quickly):

Very often
☐

Often
☐

Sometimes
☐

Hardly ever
☐

Never
☐

SECTION 7: UNDERSTANDING YOUR BODY

This section asks questions that will help us learn how much you understand about your body composition.



59. What percentage of your weight do you think is muscle and bone? _____ %

60. What percentage of your body weight do you think is fat? _____ %

61. Check the answer that best describes how you feel about your body.

Very
underweight
☐

Somewhat
underweight
☐

Just the
right weight
☐

Somewhat
overweight
☐

Very
overweight
☐

62. Check the answer that best describes how you would change your body.

Lose a
lot of weight
☐

Lose a
little weight
☐

Stay
the same
☐

Gain a
little weight
☐

Gain a lot
of weight
☐

63. Check the answer that best describes how you like the way your body looks.

A lot
☐

A little
☐

Not at all
☐

Hate how I look
☐

**THANK YOU VERY MUCH FOR COMPLETING
THE PARTICIPATION QUESTIONNAIRE! ☺**

APPENDIX 9 – Participation Questionnaire Scoring

Categories:

1. Inactivity
2. Free play (1) – By choice (does not include chores and mode of transportation to school)
3. Free play (2) – Not by choice (includes chores and mode of transportation to school)
4. Organized Sport
5. Total Score = Sum of free play (2) and organized sport

11. During recess (or spares), do you spend most of your time:
INACTIVITY; FREE PLAY 1 & 2

Talk with my friends
☐ 0

Do school work
☐ 0

Play active games
☐ 1

12. After school and before you eat supper, most of the time do you:
INACTIVITY; FREE PLAY 1 & 2

Watch television
☐ 0

Talk with my friends
☐ 0

Play active games
☐ 1

Play video games
☐ 0

Do other things
(Specify below)
__DEPENDS (0 or

13. After supper and before you go to bed, do you spend most of your time:
INACTIVITY; FREE PLAY 1 & 2

Watch television
☐ 0

Talk with my friends
☐ 0

Read books
☐ 0

Play active games
☐ 1

Do other things
(Specify below)
__DEPENDS (0 or

14. On weekends, do you spend most of your time:
INACTIVITY; FREE PLAY 1 & 2

Watch television
☐ 0

Read
☐ 0

Play active games
☐ 1

Play video games
☐ 0

Talk with my friends
☐ 0

Do other things
(Specify below)
__DEPENDS (0 or

15. During your free time, what are the three (3) things you like to do the most?
FREE PLAY 1 & 2 – ONLY ACTIVE ITEMS ARE SCORED – RANGE IS 0-3

1. _____ 2. _____ 3. _____

14. If there are other activities that you do once a week or more, please list them below:
FREE PLAY 1 & 2 – ONLY ACTIVE ITEMS ARE SCORED – RANGE IS 0-3

1. _____ 2. _____ 3. _____

15. How often do you watch television?

INACTIVITY

Every day

☐ 3

Almost every day

☐ 2

Hardly ever

☐ 1

Never

☐ 0

17. How often do you read a book in your free time?

INACTIVITY

Every day

☐ 3

Almost every day

☐ 2

Hardly ever

☐ 1

Never

☐ 0

19. How often do you play video games in your spare time?

INACTIVITY

Every day

☐ 3

Almost every day

☐ 2

Hardly ever

☐ 1

Never

☐ 0

21. How often in a week do you play active games with your family?

FREE PLAY 1 & 2

Every day

☐ 3

Almost every day

☐ 2

Hardly ever

☐ 1

Never

☐ 0

23. If you have daily or weekly chores at home (cutting grass, shoveling snow, farm chores, paper route), please list them below.

FREE PLAY 2 – ONLY ACTIVE CHORES ARE SCORED – RANGE IS 0-3

1. _____

2. _____

3. _____

24. How do you usually get to school?

FREE PLAY 2

Walk

☐ 3

Ride a bike

☐ 2

Take the bus

☐ 1

Get a ride

☐ 0

30. How many different intramural (house-league) activities have you played this school year?

ORGANIZED SPORT

0

☐ 0

1

☐ 1

2

☐ 2

3

☐ 3

4

☐ 4

5 or more

☐ 5

36. This school year, how many school sports teams have you belonged to?

ORGANIZED SPORT

0

☐ 0

1

☐ 1

2

☐ 2

3

☐ 3

4

☐ 4

41. In the last year, how many sports teams have you played on?

ORGANIZED SPORT

| | | | | | |
|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> 0 | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 | <input type="checkbox"/> 5 |

47. In the last year, how many DANCE clubs have you belonged to?

ORGANIZED SPORT

| | | | | | |
|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> 0 | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 | <input type="checkbox"/> 5 |

48. In the last year, how many SPORTS clubs did you belong to?

ORGANIZED SPORT

| | | | | | |
|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> 0 | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 | <input type="checkbox"/> 5 |

54. In the last year, how many different kinds of sports or dance lessons did you take?

ORGANIZED SPORT

| | | | | | |
|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 0 | 1 | 2 | 3 | 4 | 5 or more |
| <input type="checkbox"/> 0 | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 | <input type="checkbox"/> 5 |

APPENDIX 10 – Connor's Parent Rating Scale- Revise, Short Form

Conners' Parent Rating Scale-Revised (S)

by C. Keith Conners, Ph.D.

| | |
|---------------------------|---|
| Child's ID: _____ | Gender: M <input type="checkbox"/> F <input type="checkbox"/> |
| Birthdate: ____/____/____ | Age: _____ School Grade: _____ |
| Parent's ID: _____ | Today's Date: ____/____/____ |

Instructions: Below are a number of common problems that children have. Please rate each item according to your child's behavior in the last month. For each item, select the "How much of a problem has this been in the last month?" and circle the best answer for each one. If never, not at all, seldom, or very infrequently, you would circle 0. If very much true, or if occurs very often or frequently, you would circle 3. You would circle 1 or 2 for ratings in between. Please respond to each item.

| | NOT TRUE AT ALL (0) | SOME OF THE TIME (1) | MUCH OF THE TIME (2) | VERY MUCH OF THE TIME (3) |
|--|---------------------------|-------------------------------|-------------------------------|---------------------------------------|
| 1. Inattentive, easily distracted | 0 | 1 | 2 | 3 |
| 2. Angry and resentful | 0 | 1 | 2 | 3 |
| 3. Difficulty doing or completing homework | 0 | 1 | 2 | 3 |
| 4. Is always "on the go" or acts as if driven by a motor | 0 | 1 | 2 | 3 |
| 5. Short attention span | 0 | 1 | 2 | 3 |
| 6. Argues with adults | 0 | 1 | 2 | 3 |
| 7. Fidgets with hands or feet or squirms in seat | 0 | 1 | 2 | 3 |
| 8. Talks excessively | 0 | 1 | 2 | 3 |
| 9. Has trouble in making decisions or getting things going | 0 | 1 | 2 | 3 |
| 10. Messy or forgetful about things | 0 | 1 | 2 | 3 |
| 11. Loses things | 0 | 1 | 2 | 3 |
| 12. Needs close supervision to get through assignments | 0 | 1 | 2 | 3 |
| 13. Only obeys if it is something he/she is very interested in | 0 | 1 | 2 | 3 |
| 14. Runs about or climbs excessively in situations where it is inappropriate | 0 | 1 | 2 | 3 |
| 15. On the "hyper" or attention span a problem | 0 | 1 | 2 | 3 |
| 16. Irritable | 0 | 1 | 2 | 3 |
| 17. Avoids, expresses reluctance about, or has difficulty engaging in tasks that require sustained mental effort (such as schoolwork or homework) | 0 | 1 | 2 | 3 |
| 18. Restless in the "squirmy" sense | 0 | 1 | 2 | 3 |
| 19. Gets distracted when given instructions to do something | 0 | 1 | 2 | 3 |
| 20. Actively defies or refuses to comply with adults' requests | 0 | 1 | 2 | 3 |
| 21. Has trouble concentrating in class | 0 | 1 | 2 | 3 |
| 22. Has difficulty waiting in line or waiting turn in games or group situations | 0 | 1 | 2 | 3 |
| 23. Leaves seat in classroom or in other situations in which remaining seated is expected | 0 | 1 | 2 | 3 |
| 24. Disturbed by things that annoy other people | 0 | 1 | 2 | 3 |
| 25. Does not follow through on instructions and fails to finish schoolwork, chores or duties in the workplace (not due to oppositional behavior or failure to understand instructions) | 0 | 1 | 2 | 3 |
| 26. Has difficulty playing or engaging in leisure activities | 0 | 1 | 2 | 3 |
| 27. Easily frustrated in efforts | 0 | 1 | 2 | 3 |

MHS

APPENDIX 11 - Correlation Matrix for Study Variables by Gender

Table of correlation matrix for study variables by female

| | M-ABC-2 | ADHD Index | Hyper-activity | PQ | AEE | Step count | Activity Count | BMI (kg/m ²) |
|--------------------------|---------|------------|----------------|-------|--------|------------|----------------|--------------------------|
| M-ABC-2 | 1.00 | | | | | | | |
| ADHD Index | -.169 | 1.00 | | | | | | |
| Hyper-activity | -.099 | .565** | 1.00 | | | | | |
| PQ | .267 | -.286 | -.124 | 1.00 | | | | |
| AEE | -.242 | .112 | .266 | .030 | 1.00 | | | |
| Step count | -.335* | .088 | .161 | -.122 | .466** | 1.00 | | |
| Activity count | -.156 | .028 | .240 | -.002 | .621** | .598** | 1.00 | |
| BMI (kg/m ²) | -.204 | .151 | .025 | .064 | .642** | .089 | -.057 | 1.00 |

Table of correlation matrix for study variables by male

| | M-ABC-2 | ADHD Index | Hyper-activity | PQ | AEE | Step count | Activity Count | BMI (kg/m ²) |
|--------------------------|---------|------------|----------------|---------|--------|------------|----------------|--------------------------|
| M-ABC-2 | 1.00 | | | | | | | |
| ADHD Index | -.333** | 1.00 | | | | | | |
| Hyper-activity | -.169 | .606** | 1.00 | | | | | |
| PQ | .518** | -.163 | .056 | 1.00 | | | | |
| AEE | -.160 | -.101 | -.187 | .100 | 1.00 | | | |
| Step count | .221 | -.226 | -.001 | .502** | .297* | 1.00 | | |
| Activity count | .353** | -.278* | -.077 | .588** | .475** | .710** | 1.00 | |
| BMI (kg/m ²) | -.383** | .113 | -.157 | -.414** | .679** | -.199 | -.219 | 1.00 |

APPENDIX 12 - Two-way Scatter Plots for Study Variable by Group

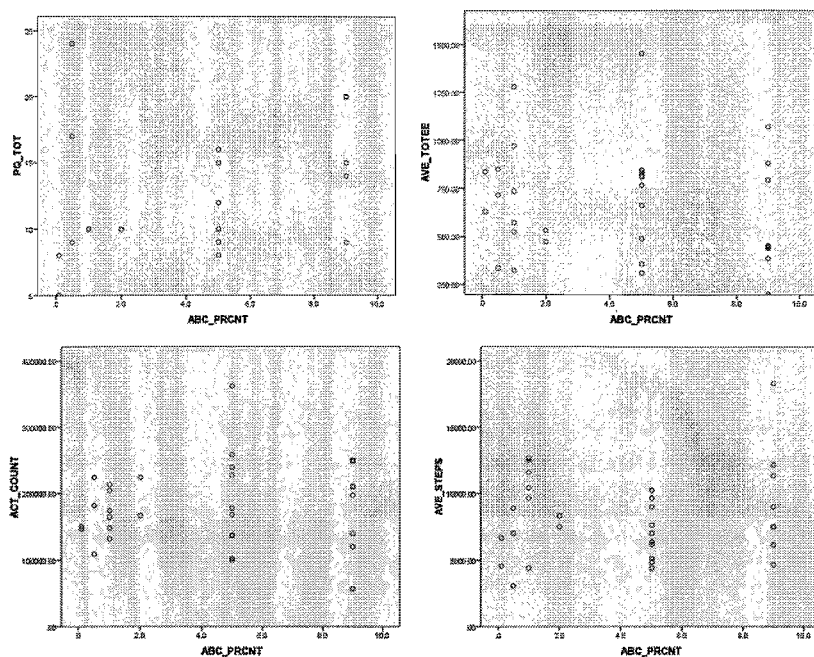


Figure 1. Two-way scatter plots for DCD of the physical activity measures: PQ, AEE, activity count, and step count by M-ABC-2

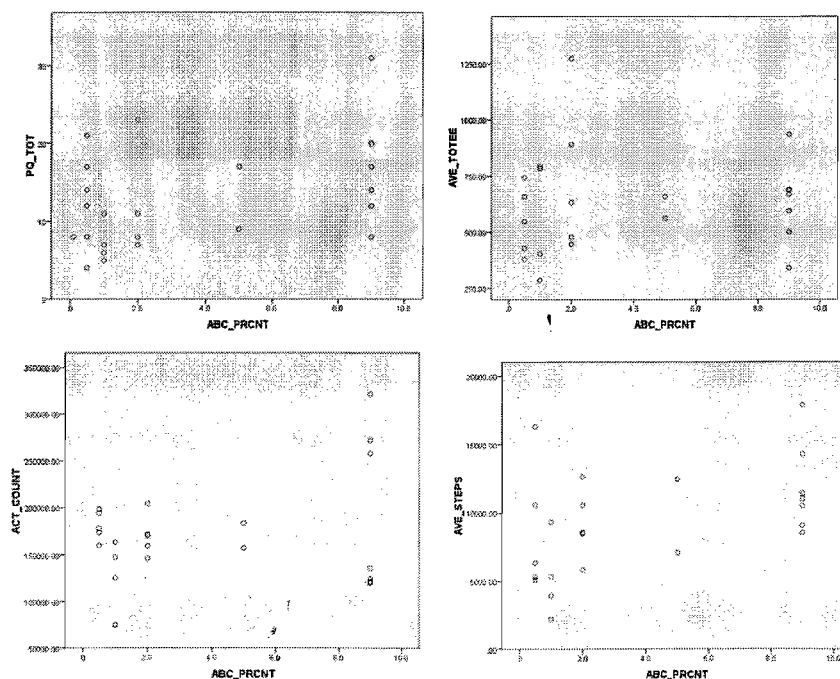


Figure 2. Two-way scatter plots for DCD-ADHD of the physical activity measures: PQ, AEE, activity count, and step count by M-ABC-2

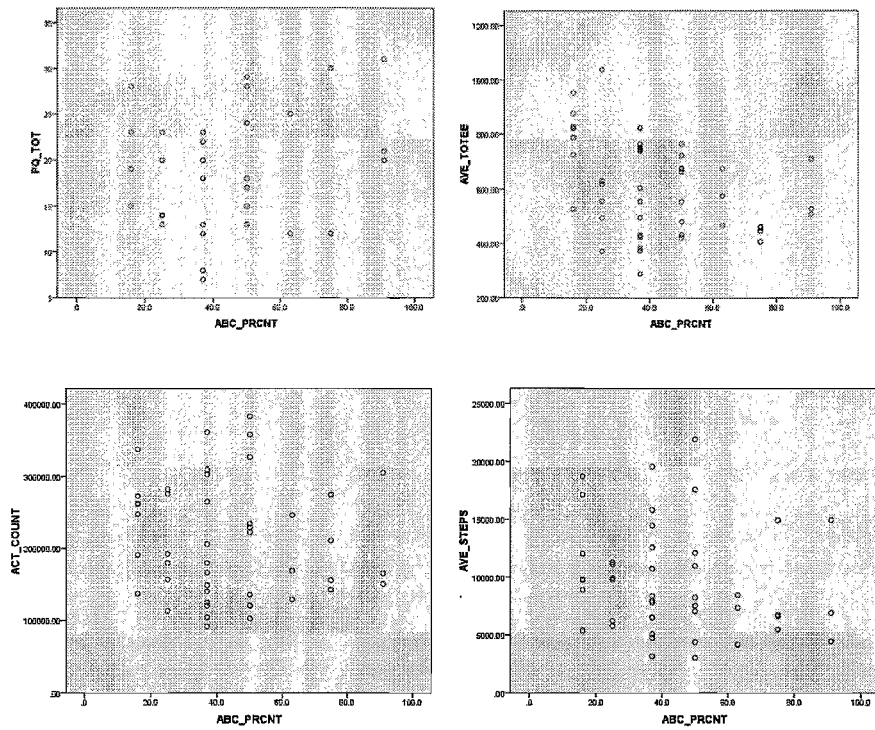


Figure 3. Two-way scatter plots for Controls of the physical activity measures: PQ, AEE, activity count, and step count by M-ABC-2

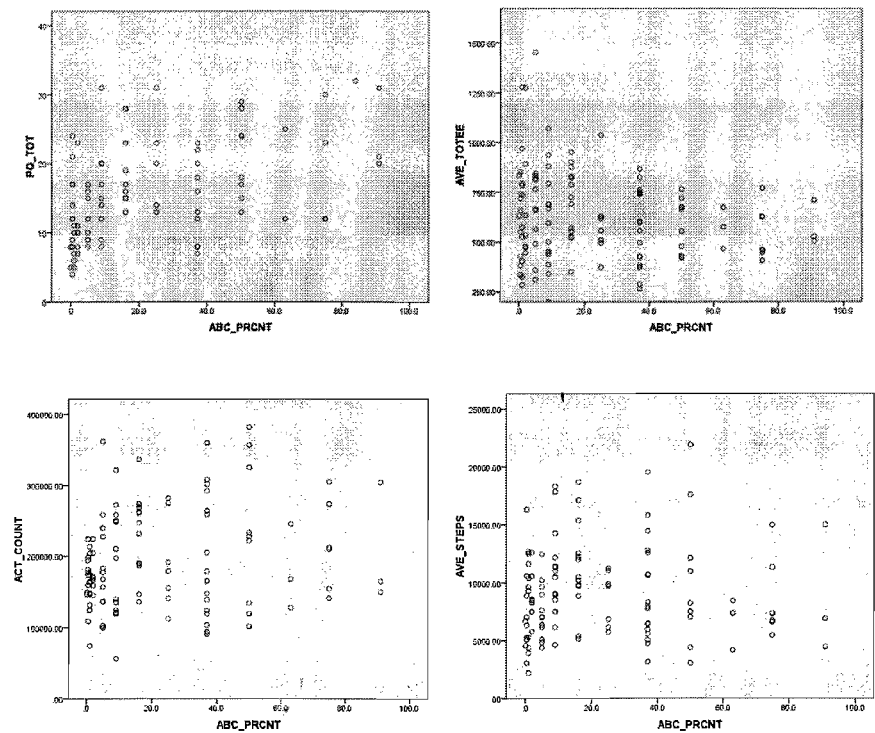
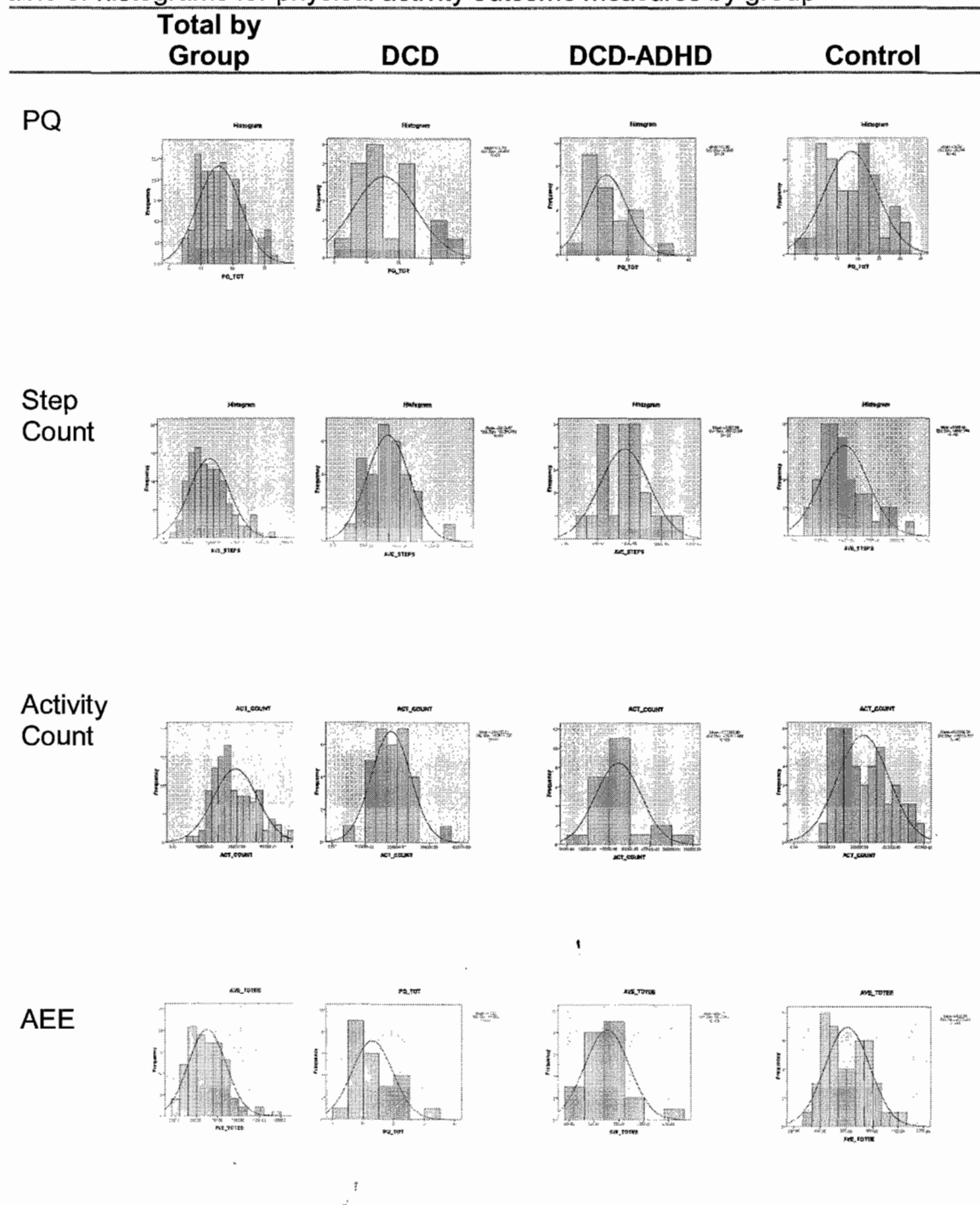


Figure 4. Two-way scatter plots for all subjects of the physical activity measures: PQ, AEE, activity count, and step count by M-ABC-2

APPENDIX 13 - Histograms for Physical Activity Outcome by Group

Table of histograms for physical activity outcome measures by group



APPENDIX 14 - Measures of Central Tendency and Dispersion by Group

Table of measures of central tendency and dispersion by group

| | | Total | DCD | DCD-ADHD | Control |
|-----------------------|------------------------|-----------|-----------|-----------|-----------|
| PQ | N | 98 | 21 | 24 | 41 |
| | Mean | 15.61 | 12.76 | 12.92 | 18.22 |
| | Std. Deviation | 6.75 | 4.88 | 6.69 | 6.28 |
| | Std. Error of Mean | .682 | 1.064 | 1.365 | .981 |
| | Minimum | 4 | 5 | 4 | 7 |
| | Maximum | 32 | 24 | 31 | 31 |
| | Variance | 45.58 | 23.79 | 44.688 | 39.43 |
| | Skewness | .575 | .685 | .934 | .254 |
| | Std. Error of Skewness | .244 | .501 | .472 | .369 |
| | Kurtosis | -.319 | -.191 | .665 | -.768 |
| | Std. Error of Kurtosis | .483 | .972 | .918 | .724 |
| Step Count | N | 99 | 31 | 23 | 45 |
| | Mean | 9078 | 8213 | 9252 | 9584 |
| | Std. Deviation | 4087.14 | 3235.73 | 3915.26 | 4647.86 |
| | Std. Error of Mean | 410.77 | 580.98 | 816.39 | 692.86 |
| | Minimum | 2200 | 3059 | 2200 | 3015 |
| | Maximum | 21927 | 18327 | 17873 | 21927 |
| | Variance | 1.67** | 1.05** | 2.16** | 1.67** |
| | Skewness | .893 | .971 | .367 | .876 |
| | Std. Error of Skewness | .243 | .421 | .481 | .354 |
| | Kurtosis | .557 | 1.69 | -.095 | .114 |
| | Std. Error of Kurtosis | .481 | .821 | .935 | .695 |
| Activity Count | N | 112 | 31 | 23 | 45 |
| | Mean | 194515.99 | 180250.51 | 172302.81 | 210369.38 |
| | Std. Deviation | 69603.47 | 60474.26 | 54313.60 | 79578.36 |
| | Std. Error of Mean | 6576.91 | 10861.497 | 11325.169 | 11862.841 |
| | Minimum | 56837.20 | 56837.20 | 74537.50 | 91332.80 |
| | Maximum | 382133.33 | 362026.14 | 321888.67 | 382133.33 |
| | Variance | 4.845* | 3.657* | 2.950* | 6.333* |
| | Skewness | .618 | .624 | 1.098 | .424 |
| | Std. Error of Skewness | .228 | .421 | .481 | .354 |
| | Kurtosis | -.183 | 1.451 | 1.873 | -.894 |
| | Std. Error of Kurtosis | .453 | .821 | .935 | .695 |
| AEE | N | 112 | 31 | 23 | 45 |
| | Mean | 625.24 | 671.18 | 625.71 | 605.09 |
| | Std. Deviation | 221.26 | 288.25 | 223.02 | 172.02 |
| | Std. Error of Mean | 20.91 | 51.770 | 46.502 | 25.644 |
| | Minimum | 200.34 | 200.34 | 284.92 | 289.47 |
| | Maximum | 1453.33 | 1453.33 | 1275.52 | 1037.05 |
| | Variance | 48954.91 | 83085.302 | 49736.519 | 29592.563 |
| | Skewness | .869 | .734 | 1.015 | .398 |
| | Std. Error of Skewness | .228 | .421 | .481 | .354 |
| | Kurtosis | 1.45 | .629 | 1.946 | -.482 |
| | Std. Error of Kurtosis | .453 | .621 | .935 | .695 |

* Denotes values that require multiplication by 10^8

** Denotes values that require multiplication by 10^7

APPENDIX 15 - Table of Descriptives for Controls with ADHD-only Group

Table of Descriptives for subjects in DCD groups of physical activity outcome measures (mean±sd). Controls with ADHD included in overall Control group.

| | | DCD | DCD- ADHD | Controls |
|-----------------------|---------------|-----------------|-----------------|----------------|
| Step Count | Entire Sample | 8213±3234.7 | 9252±3915.3 | 9619±3234.3 |
| | Males | 8795±3638.2 | 8658±2934.4 | 11426±4339.9 |
| | Females | 7292±2316.7 | 9900±4834.0 | 7235±3058.4 |
| AEE | Entire Sample | 671.18±288.2 | 625.71±223.0 | 600.51±221.3 |
| | Males | 718.52±329.3 | 623.92±263.2 | 648.33±160.7 |
| | Females | 596.24±198.0 | 627.65±182.2 | 572.78±183.3 |
| PQ | Entire Sample | 12.76±4.9** | 12.92±6.7* | 17.96±6.6 |
| | Males | 11.09±4.1** | 12.42±6.1* | 18.30±7.2 |
| | Females | 14.60±5.2 | 13.42±7.4 | 17.52±5.9 |
| Activity Count | Entire Sample | 180251±60474.3* | 172303±54313.6* | 210949±76068.0 |
| | Males | 185129±66931.0* | 173661±33450.1* | 241680±76103.3 |
| | Females | 172527±50371.6 | 170821±72487.9 | 170385±54842.6 |

Note: ** p < .01, * p < .05 significance between Controls and DCD and between Controls and DCD-ADHD

APPENDIX 16 - Mean Scores for AEE and PQ by Gender and Group

Figure 4.3 Mean scores for AEE by gender and group

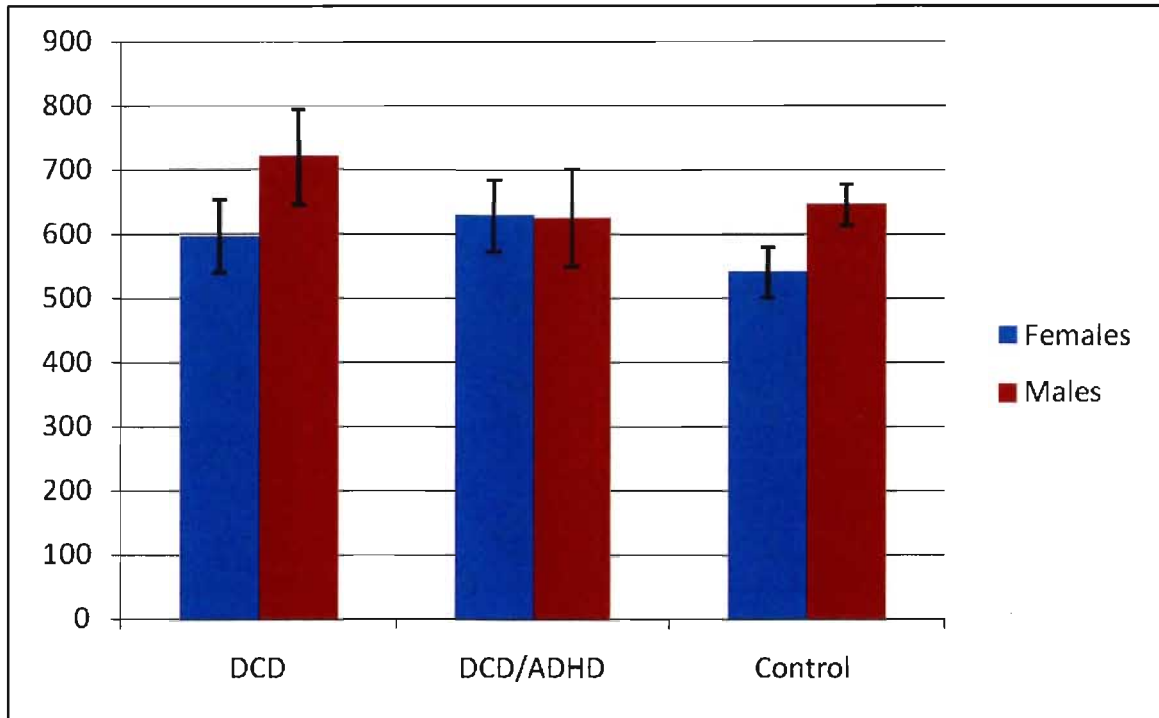


Figure 4.4 Mean scores for PQ by gender and group

